SHOP KINKS

A BOOK ENTIRELY DIFFERENT FROM ANY OTHER ON MACHINE-SHOP PRACTICE. SHOWING SPECIAL WAYS OF DOING WORK BETTER, MORE CHEAPLY AND MORE RAPIDLY THAN USUAL, AS DONE IN FIFTY OR MORE LEADING SHOPS IN AMERICA. FULL OF VALUABLE AND HELPFUL SUGGESTIONS REGARDING THINGS THAT CAN BE APPLIED TO SHOP PRACTICE.

A MOST USEFUL BOOK FOR THE MACHINIST

BY

ROBERT GRIMSHAW, M.E.

Author of "Locomotive Catechism," "Steam Engine Catechism," "Engine Runner's Catechism," etc., etc.

FULLY ILLUSTRATED

By two hundred and twenty-two new and original illustrations, made expressly for this work

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PREFACE.

About thirty years ago, on entering one of our principal iron ship and engine building works, my chief suggested that I keep a note-book or its equivalent. This advice was at once accepted, with advantage to myself, and I hope to others also. The practice has been kept up throughout a very busy life, passed in touch with important industrial establishments in the United States, Canada, and Europe, and with engineers, machinists, and scientists whose acquaintance (and in some instances friendship) I acknowledge as a rare privilege.

During a large portion of this time I have contributed editorially and over my own signature and various "pen-names" to the principal practical journals in English and French, and more recently in German, on both sides of the Atlantic. The favorable reception accorded my published articles and books emboldens me to produce this volume. Its over 500 separate items consist not only of my own and others' widely-scattered items from technical journals, notably *Mechanics*, *Machinery*, and the *American Machinist* (named in order of extent of my indebtedness), but of material either gathered from visits to well-known shops, or based on data contributed by leading machine-tool builders and users. To these latter I have given due credit not only in appropriate places in the body of the book, but in a special list on page 7; and hereby again extend my thanks.

The book was at first proposed under the name "Machine-Shop Chat"; but the large proportion of "kinks" and "wrinkles" therein illustrated or referred to warrants the change to the present title.

As "shop kinks" and "wrinkles" will always interest me, I hope that my readers will favor me with short sketches and descriptions concerning their own and others' practice, especially for unusual work and in emergencies.

ROBERT GRIMSHAW.

January, 1896.

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Colt Fire Arms Co.,	Hartford, Conn.
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SHOP KINKS

AND

MACHINE SHOP CHAT.

"The Poor Old Lathe." I was talking the other day with a locomotive builder who was greatly criticising the crossheads on a certain road because they were of the Laird type; that is, there was one heavy guide-bar above the piston-rod, and the crosshead played on that. The objection was and is, that the thing is not in line; that there is a tendency for the crosshead to be twisted fore and aft at every to-and-fro stroke, bending the piston-rod; and the greater the wear of slide and guide-bar, the greater this tendency and its effect.

The very same criticism applies to the average engine-lathe with only one feed-screw to the carriage; and the very same trouble results as soon as there is wear. But with two feed-screws, one at each side, and each of which should be reversible, the carriage would be fed along squarely; and if the lathe had only one leg at the tail-stock end, as long ago proposed by Prof. Sweet, it would stand square on any kind of a floor and not twist the bed.

Lathe-Speed Regulator. I am much pleased with a device at Norcross's, to keep the speed of a lathe uniform, no matter what the diameter of the piece being turned. As it is, on ordinary lathes, when the tool is working far from the center (say on a cylinder head or other disk-shaped piece), the cutting speed is greater than when it is working close to the center; and it is evident that, especially on large pieces, if the lathe is geared so as to give the proper cutting-speed (which is the maximum for that material, so as to get the most work per hour out of the lathe), when the tool is at or near the axial line, the speed will be too great when the tool is working further out, and may be ruinous when at the edge of a piece of large diameter. On a piece eighteen inches in diameter, if the speed is right when working one inch from the center, the average speed will be five times too great, and the maximum speed nine times too great, which would be ruinous to the tool.

If we get at it the other way and to prevent injury to the tool, and improper work, make the cutting speed right for the periphery of the 18-inch disk, the average speed, which will represent an approximation to the capacity of the lathe, will be only one-fifth as high as it should be, and the speed at one inch from the center will be one-ninth of what it should be. That sort of thing may be very satisfactory from the standpoint of preserving the tool-points, but it does not help along the capacity of the shop to get work done, nor aid in satisfying customers who (as most of them do) want their work in a hurry.

If, however, we have a belt-shifting device consisting of two horizontal belt-cones placed almost in contact, the head of one opposed to the foot of the other, and a space between them rather less than the thickness of an endless rubber belt having a length rather more than the greatest circumference of the cone about which it wraps, rotation of one cone (by "cone" I mean straight-sided conical frustum, not stepped pulley) will cause rotation of the other; and sliding the belt along from one point in the length of the two cones to another will vary and, even if desired, reverse the velocity-ratio. If the belt be embraced by the prongs of a shipper which engages in an advancing spiral parallel with the cones, rotation of the spiral will cause variation of the velocity-ratio;

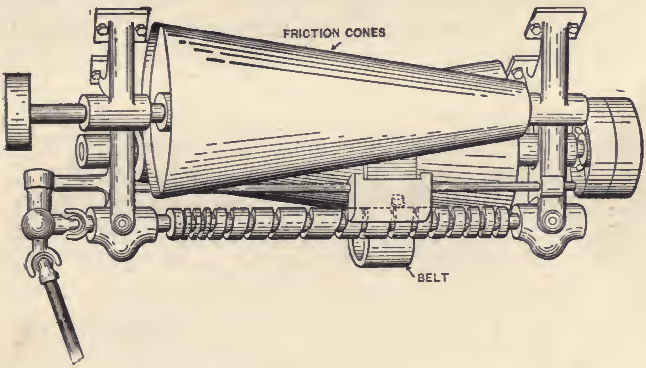


FIG. 1.—LATHE-SPEED REGULATOR (BROWN & SHARPE).

and if the spiral be specially designed with irregular pitch, any desired rate of change of the velocity-ratio between the two cones may be obtained. If the driven cone be belted to the lathe-gearing, and the prong which engages in the advancing spiral be attached to a piece which bears against the tool, or the tool-post, or the cross-slide, the motion of the tool outwards from the center may be made to cause decrease of the speed of the driven cone, so that when the tool is working on the large diameter the cutting speed may be kept just the same as when it is working on the small diameter. Figure 1 shows this most satisfactorily; the piece leading to the machine being shown cut off.

Lead-Screw Wear. The trouble with your lathe is that it has been doing right-handed work for years and years, cutting right-handed threads; and as the wear has taken place on only one side of the lead-screw its pitch has been increased since you first got it. Further, it has been used most at the end nearest the live center, and is most worn there; and as the wear increases the screw will have not only too great a pitch, all along that part of the screw which has been used, but an irregular excess which cannot be calculated for or allowed for. If it was arranged so that you could turn it end for end every now and then, you would at least have the error caused by and upon short work lessened and divided between the two ends; but for all that the pitch would not be true. The next time you get a lathe of such a construction, if you do ever get one just like it, better do your general screw-cutting on one end, and for special work requiring to be very correct, use the other end. Then if you want you can keep the wear from coming on only one side of the screw, not by cutting left-handed screws, but putting a pulley at the tail of the lathe and by a cord attached to the carriage at one end and a weight at the other making the carriage drag the screw instead of the screw pushing the carriage. This will put some of the wear on the left side of the threads instead of the right, even in cutting right-hand threads. You may say that every time the carriage is brought back there is a pressure put upon the other side of the screw-threads, but in reply to this I may say that on the back travel there is no pressure as during the cut.

Enough care is seldom taken with the lubrication of lead-screws; all the bearings may get enough oil and of the right kind, but the screw is left to collect lint and fine fillings and dirt that may drop or float that way, and is too seldom wiped clean with waste and given proper oil in liberal quantities. The bearings may be restored to truth so much more easily than the lead-screw, and wear and damage done to them is so much less injurious to the machine and to the work done on it, that it is a wonder that machinists pay so little attention below the shears.

Facing-Lathes should at least do facing rapidly and well, yet on most of them we find the cross-feed screw so fine that the work is hampered and the owner of the lathe handicapped. In the Ferracute Works there is a lathe built principally for facing, that is like the "protection that protects"; that is it faces; the cross-screw having a very coarse pitch that carries the tool across at a great rate when desired, while of course any needed degree of slowness may be obtained by hand.

Lathe-Center Spindles. There is no use in trying to do good work with improper tools. The lathe is a tool which can do good work when it is in proper order and is properly used; but if the ways are untrue and the lead-screw worn, or the center soft and out of true, the production of good work will be more by good luck than by good management; and in many instances might be classed among modern miracles.

If the lathe-center is soft it will be apt to get bent, bruised and indented, no matter how careful the workman is. Hardened centers very seldom get out of true even with heavy work or heavy cut. They also do truer work than soft ones. Of course they

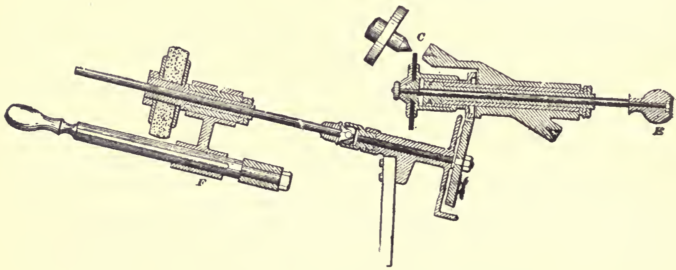


FIG. 2.—GRINDING LATHE-CENTER SPINDLES.

require grinding once in a while to keep them in perfect shape; but this is easily done, as for instance by such a lathe-center grinder as that of which I show a top view in Figure 2.

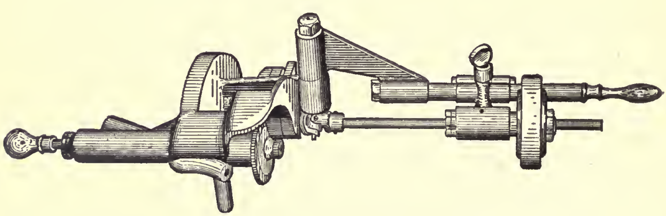


FIG. 3.—LATHE-CENTER GRINDER.

In order to operate it, the bar *A* is placed loosely in the tool-post, and the machine placed on the lathe-centers as at *BB*, screwing the tail-slide firmly. The fall-rest or tool-blocking is adjusted until the bar *A* rests squarely upon it. Then the tail-post screw is screwed up, the tail-slide withdrawn, and the lathe-carriage moved until the machine is in a position similar to *C* in Figure 4. *D* is a rubber pulley which is placed on the smallest step; and the lathe may then be run backwards with or without the back-gears, as is preferred. The cut of a fly-wheel is adjusted by the cross-slide handles of the lathe.

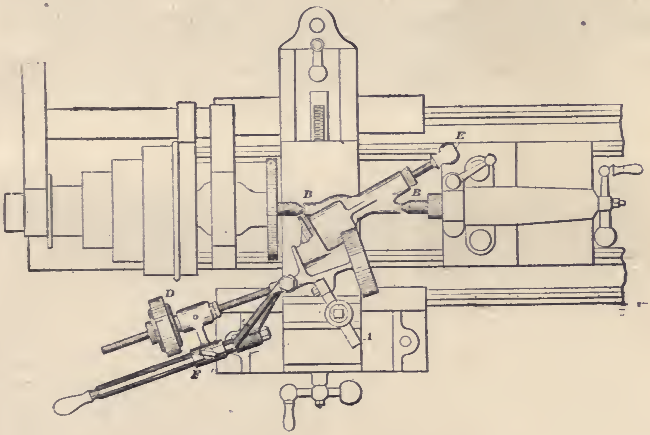


FIG. 4.—GRINDING LATHE-CENTER SPINDLES.

The wheel is moved across the surface of the center by the handle *E*. The adjustment *F* provides for different sized lathes.

The advantage of this machine is that it is entirely self-contained, requiring no belts to connect with the countershaft or cone of the lathe; there is no crank to be turned by hand. Its spindle is ground true, straight and round.

Figure 3 shows the general construction of the machine and its relative position to the lathe-center when it is ready to grind.

Lathe-Centers made like Figure 5 have the advantage of doing away with the difficulty in turning up the center, by reason of the difference in cutting-speed at the point and the full diameter of the taper. Figure 6 shows the same thing on a center cut away on one side to admit a chaser close to the center; and Figure 7 the same idea applied to milling-

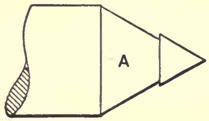


FIG. 5.—LATHE-CENTER.

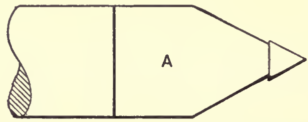


FIG. 6.—CENTER CUT AWAY ON ONE SIDE.

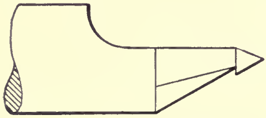


FIG. 7.—MILLING-CENTER.

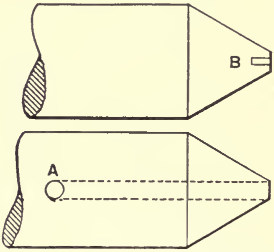


FIG. 8.—LATHE-CENTER FOR HEAVY WORK.

centers. Figure 8 shows a form for heavy lathe-work; having an oil-hole *A* pierced to the center and carried to the point as shown by the dotted lines; an oil groove *B* being cut at the bottom so that the center need not be slacked back in order to oil it.

Lathe-Centers for Heavy Work. It is said that the best outline of mold-board for plows for any given soil is that shown after a plow of almost any kind has been driven through that soil and noting the surface produced by the material which clings to the

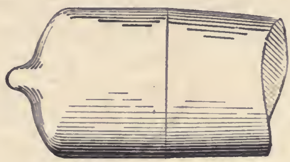


FIG. 9 —OLD CENTERS WORN TO BEST SHAPE FOR RESISTANCE.

mold-board. Where the clay remains thick on the board is where the metal should be highest. On the same principle, perhaps the proper form of lathe-center for heavy work would be that produced by

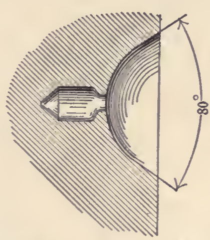


FIG. 10.—WORK-CENTER MADE WITH SLEDGE AND SET-PUNCH AFTER DRILLING.

running a cone center for years with such work, and noting the shape into which it got.

An old correspondent of *Mechanics* states that this form is about as shown in Figure 9, which we may call the center worn to the best shape for resistance, and from this he deduces as the best form to make one with an angle of 80°, terminated in a rounded end which is part of a $\frac{5}{8}$-inch ball; the hole in the shaft is to be drilled $\frac{1}{4}$-inch diameter, chipped part way out to the shape of the center, and finished with a sledge and set-punch to the same shape as the center. The swaging hardens the walls of the hole. Then with a very narrow cape chisel three evenly-spaced grooves are to be cut from the outside to the center, and the drilled hole at the bottom should be opened a little with a small center-punch.

Lathe-Centers for Cutting Off. Where there is much cutting off to be done, it may be well to have the lathe-centers formed as shown in Figure 11; there

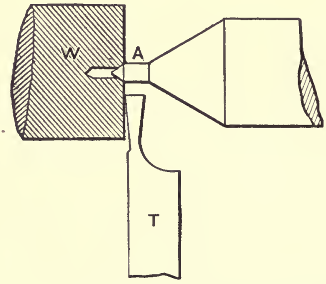
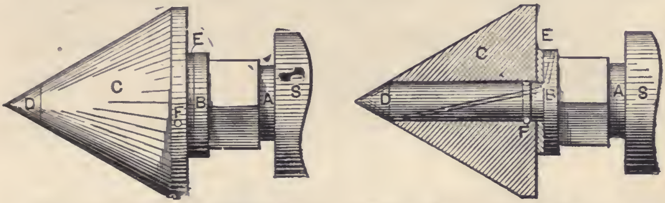


FIG. 11.—LATHE-CENTER FOR CUTTING OFF.

being a cylindrical extension with coned point which will permit the cutting-off tool to pass between the center and the work, without leaving any burr.

Centers for Coned or Tubular Work. Figures 12 and 13 show a dead center used by the Lockwood Manufacturing Company to prevent wearing at the mouth of the hole in the work without using a plug. *A* is a stem fitting into the tail-stock spindle, having a collar *B* and carrying the loose cone *C* while the stem itself is coned at *D*, in the same line with *C*. The work is supported on the loose cone *C*. At *E* is a rawhide washer to prevent cutting on the flat



FIGS. 12 AND 13.—CENTER FOR CONED OR TUBULAR WORK. (LOCKWOODS.)

surfaces. The pin *F* is one-half of its cross-section in *C*, and the other is a semicircular groove in the stem of *A*. *G* is a spiral oil-groove passing along the top of *A*, thence up through the collar *B*, so that the rawhide washer *E*, the pin *F* and the bore of the cone *C* may all be lubricated through one oil-hole.

Centering is the most important step in lathe-work; **end-squaring** being next. In light work, after

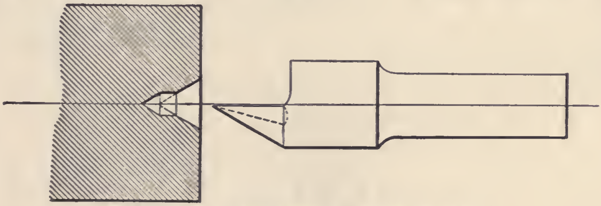


FIG. 14.—CENTERING LATHE-WORK.

drilling in the center—say with a $\frac{3}{32}$-inch drill—the center may be made with a tool such as is shown in

Figure 14; the angle being from 60° to 70° or even 75°. Such a tool will make a cone that will fit the lathe-center loosely on the inside and hence be apt to keep oiled. A trifle more than half the side of the cone should be cut away and a flat face left.

This will not do for heavy work.

Work-Centers. There are right ways and wrong ways to do most things; and work-centers and lathe-

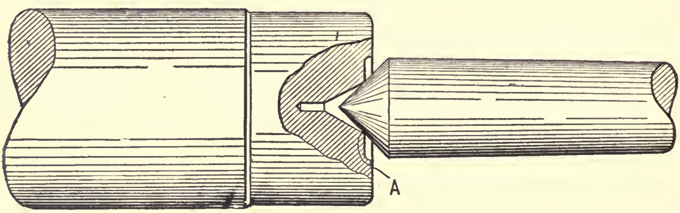


FIG. 15.—"BOTCHMAN'S FAVORITE."—WRONG.

centers are no exceptions. What the Leland and Faulconer Co. calls "John Botchman's favorite" is

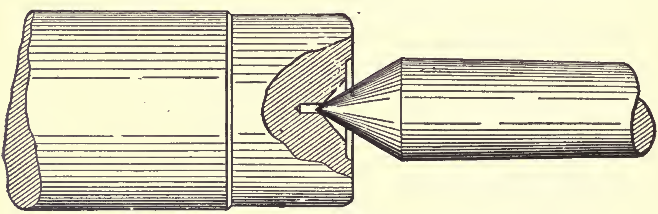


FIG. 16.—BOTCHMAN'S CENTER AND ARBOR.—WRONG.

shown in Figure 15; the lathe-center being *about* 90° and the reamed center of the arbor or shaft *about* 60°. This gives a ring of contact, only, at *A*, so that the lathe-center, if soft, is ringed at that point, and if hard the work continually shifts.

Another of his favorites is that shown in Figure 16; and this is if possible worse than the last one. Here the work-center is of greater angle than the lathe-center, and here, also, there is only a ring of contact.

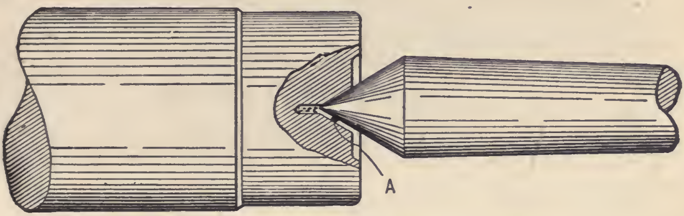


FIG. 17.—"BOTCHMAN'S DELIGHT"—WRONG.

Figure 17 is the Botchman's delight. The angle of the lathe-center and of the work-center are about the same, and as no care is taken that the lathe-center fills the work-center, there is considerable wobble, rendering concentric work practically impos-

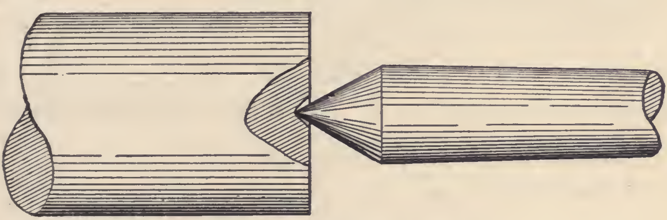


FIG. 18.—ANOTHER WRONG WAY.

sible. The drilled hole in the work will in this case afford an excellent reservoir for chips, and if the lathe-center is soft, this latter will be very nicely worn.

Figure 18 shows another favorite way of centering in botch shops. The work-center is made with a center-punch. It may be in the true center, or it may be somewhere near it; it may be truly axial, or it may be out of line. In either case it has not

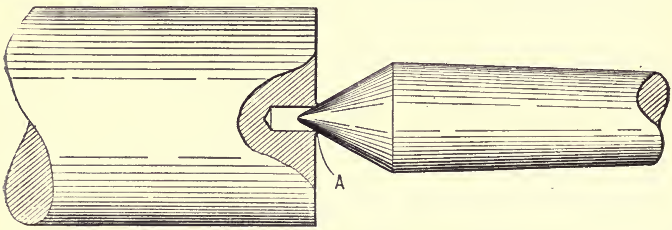


FIG. 19.—STILL ANOTHER WRONG WAY.

the same angle as the lathe-center. There is no center-drilled portion—thus effecting a saving in small center-drills. Figure 19 shows another improper method.

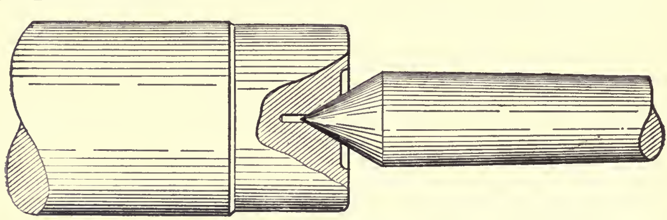


FIG. 20.—RIGHT WAY TO MAKE ARBOR AND CENTER.

Figure 20 shows the proper way to make both the lathe-center and the work-center. The former is exactly 60°, being hardened and ground. The latter is also exactly 60°, as is known by its being reamed with the center-reamer shown in Figure 42.

The point of the lathe-center is protected by the center-drilled portion of the work-center; but no chips can get in here.

Preserving Arbor-Centers. In the Pryibil shops, instead of the usual double countersink, they make

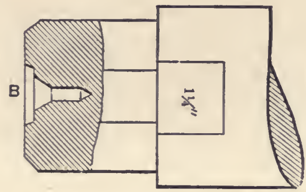


FIG. 21.—PRESERVING ARBOR-CENTERS.

arbor-centers as shown in Figure 21, putting babbitt metal at *B*.

Boring Tapers in the lathe may be facilitated by giving the boring-bar a ball center comprising about two-thirds of the diameter of the sphere, held on to the bar by a cap on the end of the latter, and having in it a countersunk and deep-drilled work-center. With such an arrangement the bar-centers cannot wear out of truth by setting it over.

Testing Lathe-Centers. Never assume that they are true. Test them. One way is to make a plain disk say ten inches in diameter and $\frac{1}{10}$-inch thick with a $\frac{1}{16}$-inch center-hole straight through it. This, if placed on the centers of the lathe when the latter are not in truth, will magnify the error and enable accurate adjustment to be made.

Again you want to find out whether the live-center and the tail-center of that lathe are in perfect alignment now that that piece is chucked. Well, if you will take a piece of iron that will reach from the tail-center to some point on the outer part of the object that is chucked, and will make a cone center in one end of it and put that on the tail-center and let the other end touch the face of the object at some point, scribing that point, and will then turn the lathe 90° and see whether the end of the gage-piece strikes it at the same distance from the live-center, and will then turn through the other quarters in the same way, you can find out what you want to know. If the radial distance is the same in all cases the centers are all right; but if the gage reaches further out at one quarter-position than at the other, they are not, and you will have to make them so before you go on with the work.

A Good Alignment-Gage for a lathe may be made by taking an iron bar half as long as the diameter of the

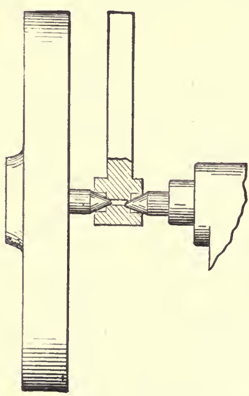


FIG. 22.—GOOD ALIGNMENT-GAGE.

face-plate, and having at one end an enlargement in its width, in which there is a small cylindrical hole bored through and then countersunk from both sides, not letting the two countersinks meet. If this is put to the centers so that one projects into each countersink without their points meeting, the bar will stand at a certain distance from the face-plate; this distance being measured, and the bar turned about so as to make first 90°, then 180°, and then 270°, from the first position, the distance of its face from that of the plate should be the same in all four positions. If they are not, the lathe is out of line; and if they are, it is all right in that respect. (See Figure 22).

Aligning Engine-Lathes is done in the Pond Works by having on the face of the face-plate and near its perimeter two steps; then in place of the dead center there is a stud carrying an arm to which there is attached a scriber as on a surface-gage. This scriber (which is curved at one end and parallel with the lathe-centers at the other, and may be turned end for end) is adjusted so as to touch the top of one of the steps on the face-plate; then it is swung around 180°. If it touches the same step at the same point in its width, the tail-stock is of the right hight. Bringing it to the quarter-points will also show whether or not the tail-stock is set right sidewise. Reversing the needle and bringing it so that it touches the face of one of the steps on the face-plate, if it just touches at top and bottom as well as at the two sides, the tail-spindle is in line. The larger the face-plate the more readily the error may be found.

Handy Lathe-Chuck. For drilling holes radially in a cylindrical bar, where they all must meet in the center and be accurately spaced, in place of the dead center, there is inserted in the tail-spindle of the lathe a chuck having its end provided with V grooves which are made true with the line of centers of the lathe, so that when the work is laid in them they will be held true. It may be well to have two grooves, one for large and one for small work, so that the side of the shaft to be drilled will not pass within the fork.

Setting a Lathe Parallel. After doing taper work it is sometimes difficult to bring the lathe quickly back for parallel turning; particularly where the tail-stock does not rest on V's and is a loose fit between the ways. If the work to be turned parallel is already roughed out parallel, the setting may be facilitated by bringing the point of a pointed tool against the work, and winding the slide-rest along. If the work is not already roughed out parallel, a parallel mandrel may be set in the lathe first and this test applied to it.

Backing off Milling-Cutters is an operation which is as troublesome as it is necessary, under the ordinary methods of working, and with the usual appliances about the average machine shop. A device for doing this properly and with no trouble is so constructed that it is only necessary to place the cutter on an arbor in the ordinary lathe, in the usual way, to put the arbor on the lathe-centers with a driving-pin in the slot in the face-plate, start the lathe and feed in the tool by the cross-feed screw as in a plain job of turning.

Referring to Figure 23, the forming tool *T* is held in the tool-post in the usual way; the cutter is borne by a sleeve turning on an arbor which has centers slightly eccentric, *i. e.*, as the arbor turns in the lathe upon the centers it has an eccentric motion of the required play necessary to give the cutter a motion to and from the tool by which it is backed off. This arbor *A* turns freely within the sleeve *B* upon which the cutter is placed, and while the arbor turns with the lathe, being driven direct by the lever *L* and driver *D*, the sleeve is driven intermittently by means of a ratchet wheel *M*, which receives its motion from an eccentric, through the eccentric-strap *N*, to which is attached the pawl *O*. The arm *a* is

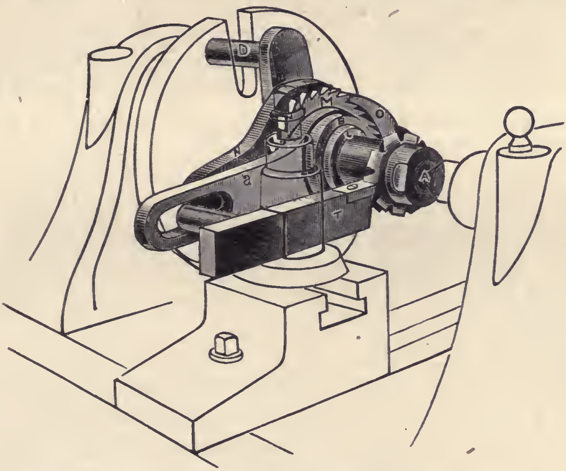


FIG. 23.—BACKING OFF MILLING-CUTTERS. (BALZER.)

for the purpose of keeping a friction on the ratchet-wheel *M* to prevent the sleeve *B* from rotating continuously with the lathe, the desired amount of friction being adjusted by the nut *b*. Between the arm *a*, the ratchet, and the nut *b* are two fiber washers to prevent unnecessary wear.

The throw of the eccentric which drives the ratchet can be decreased or increased in order to change the travel of the pawl *O* to correspond to the number of teeth desired in the cutter. This is adjusted by a lever *L*, (not shown in the cut).

Thus the cycle of operations of the device is as follows:—

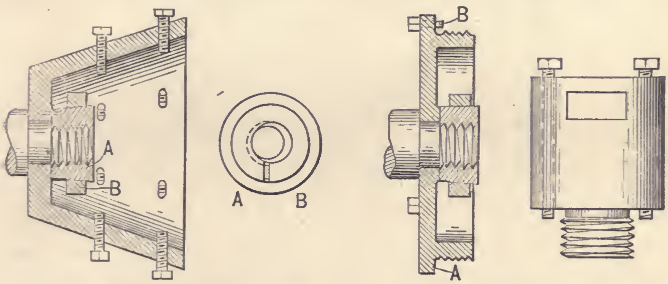
Suppose the tool to be starting at what is to be the cutting edge of a tooth in the cutter, the latter is slowly rotated and at the same time moved toward the tool to give the required clearance. When the next gap in the cutter is reached, it stops rotating and at the same time recedes from the tool until time for the cut to begin on the next tooth, the lathe running steadily all the time and making as many revolutions as there are teeth in the cutter, while the cutter rotates but once.

As the arbor *A* is continuous from end to end of the device, the cutter is held quite rigidly, and as this arbor is in precisely the same position upon the centers during the cut upon each tooth, all the teeth must be alike.

This device will back-off cutters having 9, 12, 18 and 36 teeth, by setting the pawl to take either 1, 2, 3 or 4 teeth of the ratchet at each rotation of the lathe-spindle. The pawl can be set by loosening the nut on the left side of the tool and moving either to or from the center, to change the eccentric-throw.

Bell Chucks. The Direct Separator Co. has occasion to use two bell chucks on the lathe for every different size of separator. To avoid the cost of threading these numerous chucks on the lathe-spindle, the plan shown in Figure 24 has been adopted. The chucks are simply bored and faced to fit the nuts and shoulder of the lathe-spindle, and one nut does for all chucks.

To remove chucks from the lathe-spindle, if put on in the ordinary way, is troublesome; but with the nut shown it is only necessary to drive the ring *B* off the conical surface of the nut *A*, which is split open; then the whole can be run off by hand. In the work referred to where a piece has been threaded at one end and as it is held in the chuck (see Figure 24) it is screwed on to piece Figure 26 to thread the other end. If the piece were allowed to screw up tight against the shoulder as at *A*, it would be forced up so tight as to come off hard. To avoid this, two or

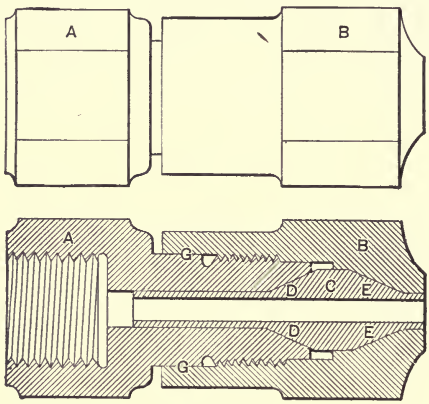


FIGS. 24 to 27 inclusive.—BELL CHUCKS (DIRECT SEPARATOR CO.).

more set-screws as at *B* are screwed up tight against their heads, and the points faced off true. The piece to be threaded is allowed to screw up tight against the points of these screws, and after the work is finished, slacking back the set-screws allows the work to be removed readily.

Figure 27 shows the application of the same principle to a plug for screwing on screwed heads.

A Spring Lathe-Chuck for brass-work, used by the Hancock Inspirator Co., is shown complete in Figure 28; Figure 29 being a mid-section, and Figure 30 a side view of the split gripping-piece and an end view of the split piece. It has only three pieces: *A* screws on



FIGS. 28 AND 29.—LATHE-CHUCK.

the spindle and takes one end of the work; *C* grips it; *B* screws on *A* and takes the other end of *C*. This last has a double cone *D E* and is split in three, nearly

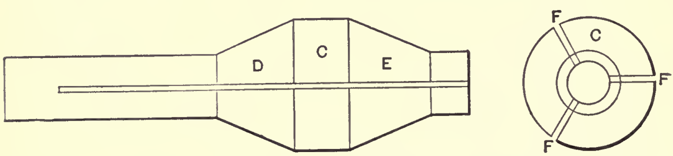


FIG. 30.—SIDE AND END OF SPLIT PIECES.

full length (as shown at *F*), so that when *B* is screwed on it the two cones on *A B* compress *C*.

Work-Drivers for Lathes. The ordinary bent-tailed dog tends to spring long and slender work on all cuts and even heavy short work on roughing cuts. The straight-tailed dog has rather less of this tendency, especially if it have two tails and is driven by pins in

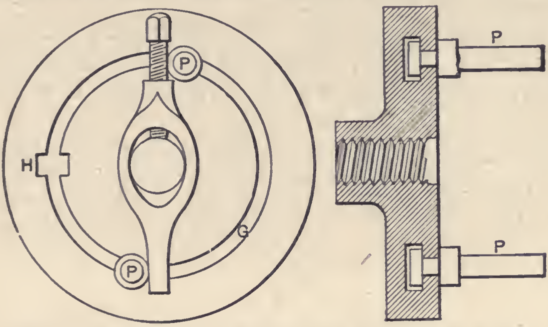


FIG. 31.—SECURING DRIVING-PINS TO FACE-PLATES (S. A. WOODS MCH. CO.).

the face-plate. The face-plate shown in Figure 31 is used by the S. A. Woods Co. It has an annular T-

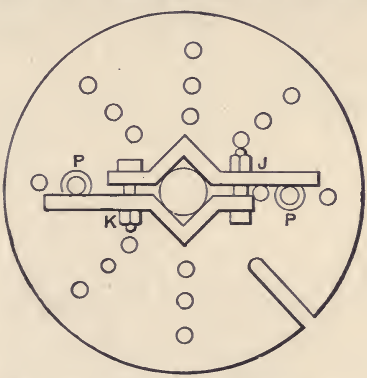


FIG. 32 —TWO-PART CLAMP-DOG.

groove with a cut at *H* to admit two nuts into which are screwed the pins *P*, which may be tightened lightly so as to come to an equal bearing on the clamps, under the pressure of the work; after which they may be tightened.

Another way is shown in Figure 32, being a two-part clamp with driving-pins *P* in holes equi-distant from the lathe-center; but in this as in the last there may be unequal drive.

The Clements driver, shown in Figure 33, has in the driving-plate *F* four slots, two of which, *A* and *B*, pass clear through to admit shouldered bolts *C* and

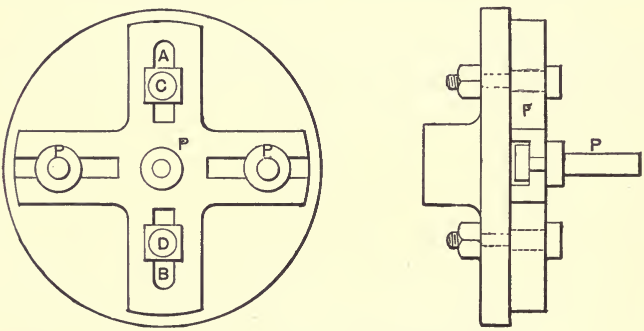


FIG. 33—LATHE-DRIVER (FRANK CLEMENTS).

D, which fit firmly to the lathe face-plate but easily in the plate *F*.

The other two slots are T-shaped, receiving nuts into which are screwed the pins *P P*. The bolts *C* and *D* drive *F*, and the pins *P* drive the work, the motion of *E* on the lathe face-plate equalizing the drive.

Driving Work Held in Lathe-Bearings. In some of Sir Joseph Whitworth's lathes, as for turning fly-wheels and their shafts, the shafts run in their bearings instead of on centers; this causes the work to be true with the journals (although it does not necessarily make the wheel balanced). For driving the shaft on such work it is well to have a "wabbler" consisting of a piece having one end squared and the other end cupped with a square socket to receive the squared end of the driving-shaft; the small squared end of the "wabbler" fitting into a squared socket fastened to the driven shaft by set-screws.

With this wabbler it makes no difference whether the driving and the driven shaft are in line or not.

A Convenient Lathe-Driver for small cored pipe and cock work is that employed by the Hancock Inspirator shops and shown in Figure 34. The hub *W*, screwed on the driving-spindle, carries the rods *B* and

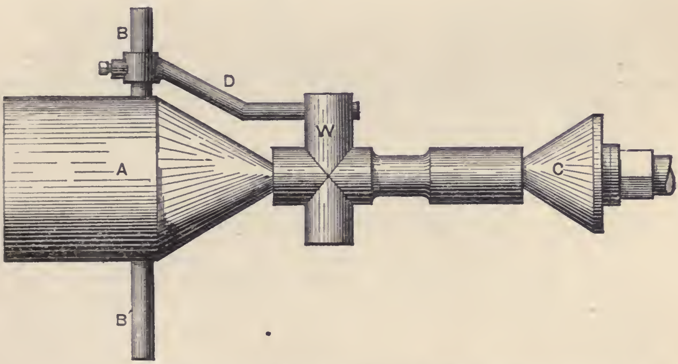
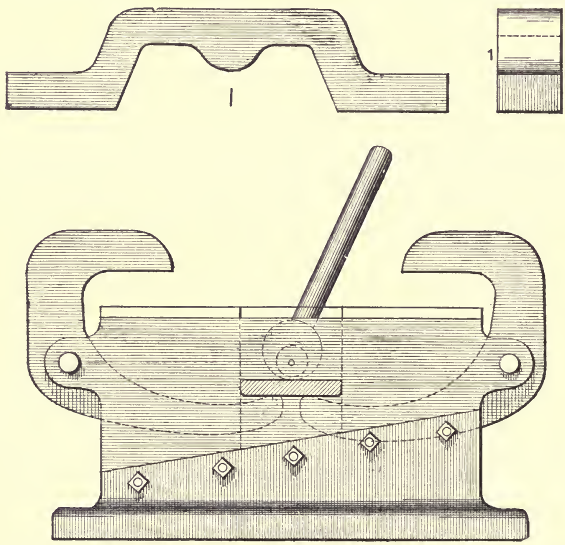


FIG. 34—LATHE-DRIVER FOR SMALL CORED PIPE AND COCK WORK (HANCOCK INSPIRATOR CO.).

B[1], each of which is adjustable for length so that *B* may be set out to suit the work and *B*[1] set out sufficiently to balance *B* and *D*. The driving-arm *D* is adjustable along *B*. The other end of the work is shown centered in a loose conical frustum such as that shown in detail in Figures 12 and 13.

A Handy Eccentric Vise for holding a special job is shown in Figures 35 and 36, as it was designed by Foreman Tretch, of the Riehlé Testing Machine Co. A great number of pieces *I* were to be faced on both



FIGS. 35 AND 36.—HANDY ECCENTRIC VISE (RIEHLÉ BROS.).

sides 1 and 2; and as the milling-machines were busy, the device was arranged to be used on the cross-slide of a lathe. As the pieces were brass, high rotation-speed was used on the milling-cutters which straddled the sample *I*.

The inclined plane admitted of adjustment as to height to suit the cutter-diameter, and the pieces were set and clamped by the eccentric-roller, and bell-crank lever in a minimum amount of time, and a considerable saving in output was effected over a moderate-speed milling-machine.

Turning Large Bars which are liable to spring may be rendered more easy and accurate by having a two-part "doctor" or center-rest with a very large opening, which is bored out on the lathe so that it will be axially true, and then the bore recessed the same as an ordinary eccentric-strap. Inside this there rotates a ring representing the eccentric-sheave, and having on its face projections by which the piece to be worked is gripped, so that its ring rotates with the work-piece, in the doctor proper. This is a California wrinkle.

In Turning Shafting (which no one does nowadays unless he has to, as it may usually be bought so much cheaper than any one can make it who does not make a specialty of it) the work may be cheapened and improved by having, instead of a center-rest that does no work, one which will rough off the bar; in other words, by having an internal mill—fluted and tempered, and ground to the size desired.

Tool-Rests. At the old Freeland Works they used to have lathe-tool rests, the top of which had a hub threaded externally to receive a ring nut around whose edge there were numerous holes to receive a pin for operating the nut. The tool-post was central in the hub. When the tool was loose the ring might be operated by hand; but when it was not it might be gripped and the ring nut operated by a pin. This is good for large lathes.

Brown & Sharpe use in their tool-posts two adjusting and gripping screws, one front and the other back, on which sits a gib on which the tool is placed. The top of the tool-post slot has a cylindrical convex surface so that it will bear only along one line of the tool; this latter being supported along the whole length of the gib. The absence of a set-screw at the top of the post enables a better view to be had of the tool.

Stiff Slide-Rests may be made by having the slide overhanging on the left side only, so that when it is used on short work (which is the most common), and on facing work (which is where the rest requires to be stiffest), the non-overhanging part gets the strain. If the cross-slide is made the lower one, the rest will always face the work square, even if the upper slide is set to turn taper. The tool may be clamped by two bars, each of which has two screws, with sufficient space left at the ends of these bars on the short side to admit of the tool being gripped between their free ends and the rest. These clamps are more convenient for boring than the ordinary tool-post.

Steady-Rest for Tapering Work. The form of steady-rest shown in Figure 37 was devised at the old Freeland Works for steadying in the lathe such square taper blanks as billiard cues are made of. The usual stand has bearing in it a ring *A*, that has four inward projections *B* in which there slide easily but closely the steadying-jaws *C*, which are pressed to the work by spiral springs. These jaws thus steady and center the work at no matter what point in its length, and have the advantage that they can lead instead of following the cutting-tool, so that the work is steadied on both sides of the cut.

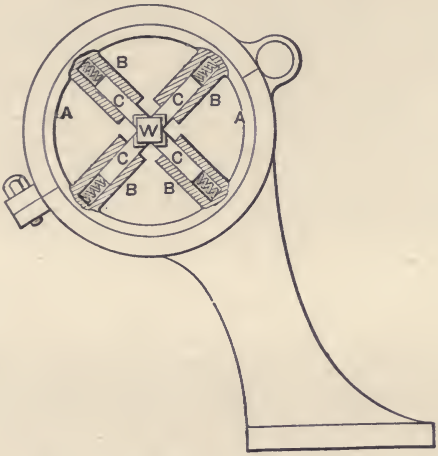


FIG. 37. STEADY-REST (FREELAND).

Breaking of Tool-Clamp Bolts sometimes causes trouble and loss of temper, and is apt to occur not

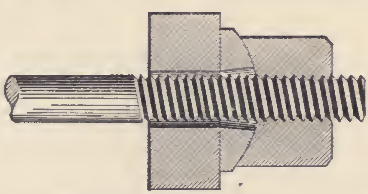


FIG. 38.—TO PREVENT BREAKING TOOL-CLAMP BOLTS.

only where the work is roughly handled, but with ordinary handling where irregularly-shaped tools are used. To prevent his, such appliances as are shown in Figure 38 may be used, there being an ordinary washer, a plano-convex washer, and a plano-concave nut. With these there is play enough to give the bolts a better show, while the grip is as tight as need be desired.

Swivel Tool-Holders having cutters so adjustable that they can not only be swiveled round and then fixed to any desired angle but be made to project at pleasure to any required distance to reach and cut into all sorts of difficult and awkward curves are in use by Smith & Coventry, of Manchester (England). The steel used for the cutters is of a deep V section, having its lower angle slightly rounded.

Angle-Gages for Lathe-Tools will be found desirable to have about the place. One block may have in it half a dozen notches; say 35, 45, 60 and 90 degrees with one side perpendicular to the block-face; one notch for parting-tools, etc. Reversing the plate makes the gage right for tools of opposite "hand," and the perpendicular-sided notches are of course all right for angles where one side is perpendicular. Smith & Coventry seem to be the originators of this.

To Take a "Hog Cut" on very small and comparatively long shafts, and to avoid the necessity of shifting a ring doctor along as would be necessary where the whole length of the shaft was to be turned down, provide a hard steel angle-block which will receive the thrust of the tool, placing this at such a point that it will just take in the shaft between it and the tool, when the right size is reached. This is held by the tool-post and enables the entire amount to be taken off in one cut, when it is started. The crotch of the angle may be directly opposite the tool, or one of its sides may be vertical and the other horizontal; the angle being ninety degrees in either case.

Tool-Post Slots in lathes are usually too small; especially in these days when many machinists prefer to use a "patent" tool-holder of iron, holding a "bit" of steel. But the post-slots are too small, not for this reason alone, but because they do not enable the use of tools large enough to carry away the heat fast enough. I agree with the late Robert Briggs, of Morris, Tasker & Co., that the smallest solid working-tool for iron should be 1¼ inches, with ¾-inch steel in the shank; and 1¾ inches by 1⅛ inches is not excessive for tools for a 30-inch lathe; while for a 48-inch lathe there should be a slot 2¾ inches or even 3 inches by 2½ inches, with a 2-inch screw.

Feed-Gage for Lathes. Ordinarily, as where two nuts are used for feed-gages for a number of pieces, it is necessary to take all the roughing-cuts first and then finish. This makes an extra cost and delay for chucking, which may be done away with by having a third nut, split so as to clamp when necessary; setting this to the finishing size, and so first taking the rough cut, then throwing in the split nut and taking the finish cut to gage.

Chucking Shafting-Boxes. In the Lane & Bodley shops, when it is required to turn the spherical face of a shaft-box true to the axis of the box-bore, a half-round mandrel is fastened to the face-plate, and the half bearing is clamped on it by bolts and plates, so that if the half-round mandrel is set true the bearings will be true also. The tool-point is made to travel in the arc of the circle by a former on the side of the cross-slide. The slide is kept in contact with the former by a weight and cord.

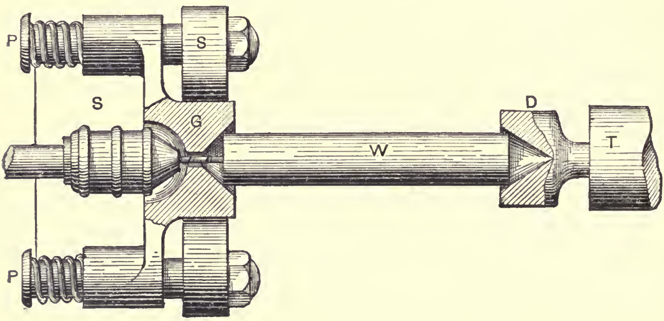


FIG. 39.—CENTER-DRILLING DEVICE. (TOP VIEW.)

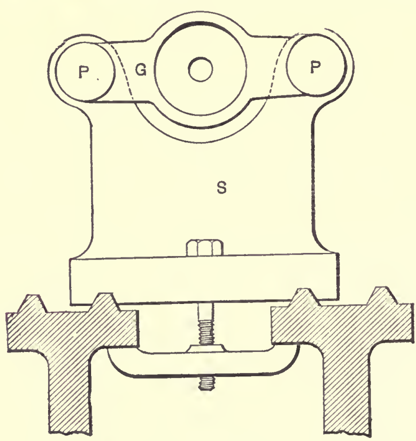


FIG. 40.—CENTER-DRILLING DEVICE. (END VIEW.)

Center-Drilling Device. The rig here shown, and which I believe originated in Hartford, consists of a stand *S* bolted to the lathe-shears and carrying studs that act as a guide to the head *G*, which has a hole coned at each end. *G* has arms which slide on the pins *P*, and against two spiral springs which surround them. The work is forced up to *G* by a cup chuck *D* in the tail-spindle *T*. It allows the use of any kind of a drill.

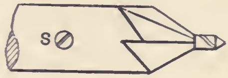


FIG. 41.—COMBINED DRILL AND COUNTERSINK.

A Combined-Countersink and Drill is shown in Figure 41, the drill passing through the countersink and being fastened by the screw *S*.

Center-Reamers. There is no question about it that the best angle for lathe-centers is 60 degrees; and there should be no more question that work-centers should be the same, and should be *centers* instead of merely depressions somewhere in the end of the work.

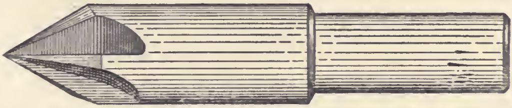


FIG. 42.—CENTER REAMER. (60° ANGLE)

What every shop should have is a center-reamer such as is shown in Figure 42, which is made and ground accurately to a 60-degree angle, and which will insure that the center in the work is exactly the proper angle.

Rose-Bit Reamer. In the Dickson Manufacturing Company's locomotive shops they have a reamer which is somewhat similar to a rose-bit, the cutting being done by beveled edges at the end of the tool, and not by flutes. To enable it to discharge its chips and not get clogged there are two or more S-shaped grooves crossing each other on the end of the tool; the chips curling away from the cutting edges into these grooves and thus escaping. The edge of the flutes is radial.

Gage for Turning Tapers. "Cut and try" is no way to turn tapers, especially if there is a collar on a male piece that is to be tapered. To facilitate such work it is best to have a gage like that shown in

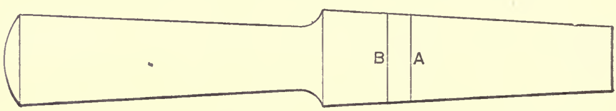


Fig. 43.—Gage for Turning Tapers.

Figure 43, on which there are two marks, *A* and *B*, the distance between which represents the amount to be allowed to make a drive fit.

Centering-Device. Back in 1878 Mr. A. L. Crosby showed to me a centering-device for round stock, cut to length in a cutting-off machine. As may be seen from the illustration, Figure 44, there is a cone or cup *A*, having a handle in which latter there is a spiral spring *C* which presses out a center point *B*. If the bore in which *C* plays is at right angles to the rim of *A*, and is properly centered with relation thereto, the cone will bring the center of objects of circular section to the point of *B*—always provided that this is central with *B* itself.

Cast-Iron Lathe-Tools. After you have got tired paying a tool-maker to forge and grind up tools for turning off those cylinder-heads, you will try cast-iron tools, made out of car-wheel iron and nicely chilled. They will take a greedy bite and not get discouraged; will stand four or five grindings, and will not require grinding so often as the steel tools.

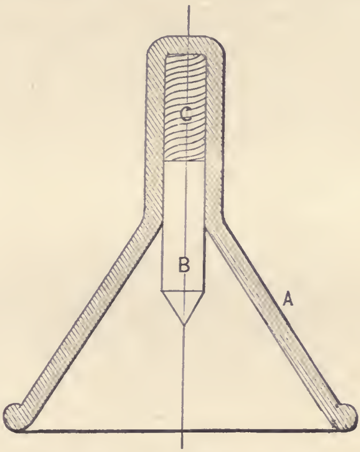
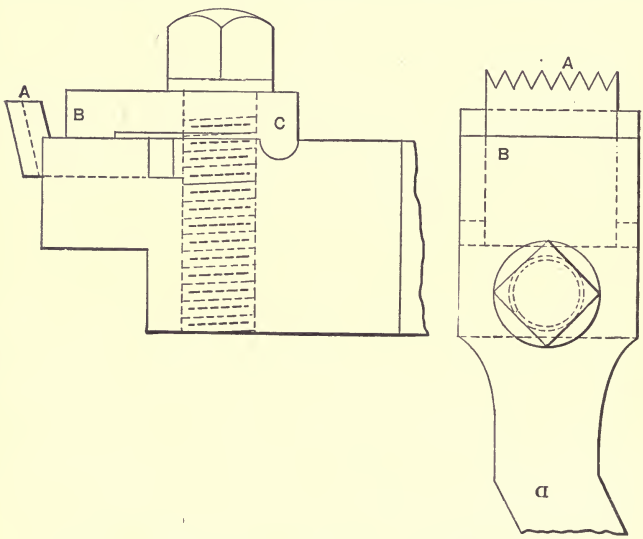


FIG. 44.—CENTERING DEVICE.

Turning Brass Balls. If you have brass balls to turn down smooth enough to be used for check-valves you may do it best (after the tit has been cut off, by which they were held for a preliminary turning) by a ring or short tube of tool-steel bored and ground on the face so that its inner edge has good cutting capacity, and capped with a wooden disk so as to make it handy to be held against the ball, while the latter is rotated by means of a wooden cup chuck covering about two-fifths of its surface.

Clearance and Rake of lathe and planer-tools may very readily be compared and noted by setting them on their backs on a level surface and setting an ordinary steel square up on edge alongside of them.

Chasers would seem at first thought to be antiquated devices, and in shops of the middle class they are considered absurd; but they are still to be found in country machine-shops and in establishments of world-



FIGS. 45 AND 46.—CHASERS (PRATT & WHITNEY CO.).

wide renown. The Pratt & Whitney Company uses them of the form shown in Figures 45 and 46 for roughing out. The chaser itself, *A*, being short, is cheap to make; the clamp *B* is recessed in the middle so that it bears only at the ends and hence grips very firmly; while the curved lip *C* adjusts it fairly well on the chaser.

Turning Chilled Rolls. Those who have essayed turning chilled rolls for the first time have not been pleased with the experiment and usually not satisfied with their success. It is an art in itself; an art which perhaps the late Morton Poole, of Wilmington, Delaware, did more than any other one man to bring to perfection—and to perfection he certainly brought the grinding of chilled calender-rolls for paper-making. Before, however, the grinding operation is commenced there must be as nearly perfect work done by the lathe as it is possible for such an imperfect machine-tool as

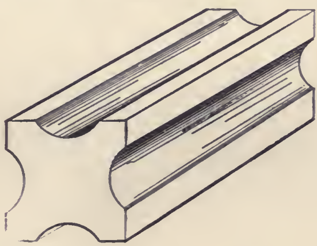


FIG. 47.—TOOL FOR CHILLED ROLLS (J. MORTON POOLE & CO.).

a lathe to perform; but most tools for this work have the double disadvantage that they do not do good work and do not work fast enough. The work reminds one of the Scotchman's porridge, "cold, burned, sour and gritty; and damn it, there was not enough of it." But by the use of a simple tool, such as is shown in Figure 47, the work is rendered very easy, and its quality, for lathe-work, leaves nothing to complain of.

A plain bar of tool-steel is taken, about one and one-quarter inches square, and about four inches of it cut off, and then fluted on each side with a semi-circular channel of about three-eighths inch radius. All four sides of the bar being then ground so that the four angles are exactly 90 degrees each, the tool is ready to be clamped in the tool-holder and set to work. It does not remove curls of material, but takes off a series of brittle thread-like turnings, about the size and general shape of pine-needles. When one band four inches wide is turned, the tool is moved along.

Boring Curved Nozzles with straight tools is not so difficult as might be thought. The tool required is a simple wedge having a thickness equal to the smallest diameter of the nozzle, and a *diagonal* at the base, equal to the largest nozzle-diameter. These tools are readily sharpened. It was about 1873 or 1874 that I had a good deal to do with competitive tests of steam fire-engines and with the improvement of such engines, and when the acceptance or rejection of an engine was based on its beating the stream thrown by another, and when also there was from $5,000 to $10,000 bet on the result as a side issue, the nozzle played (no pun intended) quite an important part. I had a number of nozzles made for this purpose, many of them at the Pusey & Jones shops by Harry English (who was one of the best brass turners I ever saw). English made for me, from my sketches, nozzles having a curved taper, with which the stream of one engine was raised from 307 to 318 feet with the same conditions of steam-pressure, wind, etc. There are now several hundred curved gun-metal nozzles thus bored in use in American fire departments, where they drove out the much vaunted "ring" and "straight-taper" nozzles, and have never been excelled except by some glass-lined tips which I brought out still later, and with which some of the world's records were made.

Turret-Lathe Tool. A very efficient tool for use in a turret-lathe of either the "Monitor" or the "Revolver" type is one which I saw in use in the Brown & Sharpe shops. It is intended to do better work and more work than is ordinarily done with a plain tool for reducing stock.

Ordinarily, there is a cylindrical head fastened to a cylindrical shank, which latter fits into the socket in the lathe-turret; this head is hollow and bears three tools which project radially inward and which, as the tool is presented to the end of the stock to be reduced in diameter, crowd off material in a way and at a rate which are far from satisfactory. In the tool which attracted my attention in the Brown & Sharpe shops these inwardly projecting cutters are not radial but are inclined so as to give them rake, so that each one acts like a properly formed and set lathe-tool; and the effect is a very greedy yet smooth cut, consuming less power for a given cut, and heating the material less, also, for a stated amount removed per minute, than where the ordinary cutters are used. Half the roughing is done with a head having three such raking cutters; the finishing is done with one having one cutting and two steadying or centering-tools, the result being a fast "sweet" cut and handsome finish.

Boring and Threading should be greatly facilitated by the use of a tool which I have seen in some of the Eastern shops, and which I show here, as applied in the tool-post. There is an offset bar of drop-forged steel which is inserted in the post; this has a split bore through which is clamped a round bar of cold-rolled steel, turned down and threaded at one end to receive either one of two caps. One of these caps has a hole through which a self-hardening steel cutter may be thrust at right angles; the other, a cap for the reception of a similar cutter at an angle of 45°. Centered in the end of the rolled-steel bar there is a tool-steel pin, against which, when the cap is screwed

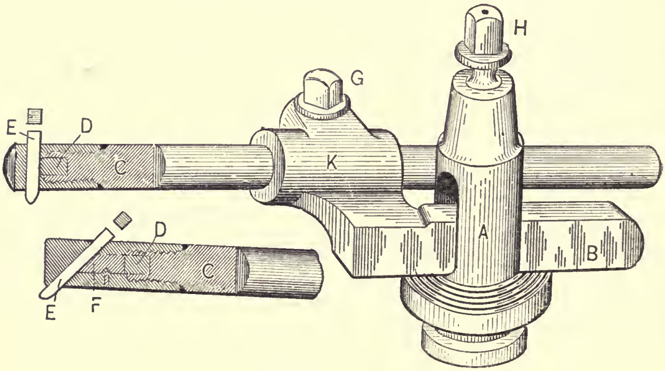


FIG. 48.—ARMSTRONG TOOL-HOLDER.

up, a similar tool-steel pin is screwed, holding the cutter in place. (See Figure 48). There is a special wrench (see Figure 49) the round side of which slips over the cap on the end of the bar, the slot engaging the cutter by which the cap is screwed up, pressing the cutter

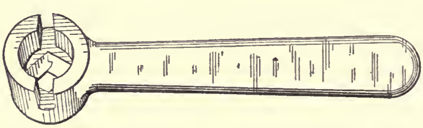
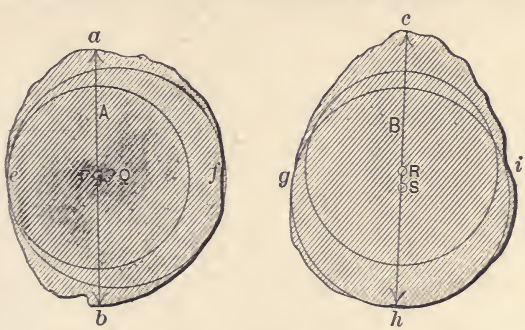


FIG. 49.—WRENCH FOR TOOL-HOLDER.

against the hardened-steel pin. The square side fits the steel collar-screw in the split hub. Such a tool should do away largely with forging, dressing and tempering, and save tool-steel, time and annoyance.

Center-Holes for lathe-work should be countersunk only enough to permit the piece to be squared off; then they should be countersunk again, because if the piece is not square-ended at the time of the first countersinking, the countersink will cut more to one side than to the other, leaving, when the piece is cut off square, a wider bevel on one side than on the other; then the axis will be changing as the piece wears.

Centering Lathe-Work. "Things are not always what they seem." One of the cases in which this is so is where work in a lathe is calipered at only one diameter, or that diameter is found at which the sides are equi-distant from the center as shown by their touching the lathe-tool equally. The center thus found will not necessarily give the largest piece that can be got out of the stick. For instance, in Figure 50, the points *a* and *b* are equally distant from the



FIGS. 50 AND 51.—CENTERING LATHE-WORK.

temporary center *P*; but by reason of the nearness of the point *e*, a much smaller cylinder could be turned out than if *Q* were the center. The same thing is shown again in Figure 51 at *B*, where *c* and *h* are equally distant from the point *R*, but a very much smaller circle can be inscribed with that as a center than by using *S*. In the piece *A* the points *e* and *f* are much better indications than *a* and *b*; and in a piece of the shape of *B* there should be three points calipered.

Tool-Points Breaking. If you have ever had the point of a lathe-tool break off in cutting V-threads, especially on tool-steel, you will be glad to try, next time, the plan of filing with a three-cornered file, on the same inclination as the thread, a place about the depth of the thread for the tool to run into.

Fluting with the Lathe. To cut reamer-flutes in a lathe, grind a side-tool with the desired clearance and set its top edge level with the lathe-center, divide the spandrel-gear circumference into as many parts as there are to be flutes, and mark the division-points with chalk; then traverse the lathe-carriage back and forth by hand, using the spandrel-gear as an index to get the distance between flutes right. Divide the shank of the reamer into quarters by means of the spandrel-gear, using a pointer-tool. For a half-round taper reamer it will be necessary to be sure that the lathe-centers are set straight before commencing, else the flutes will not be equally spaced.

Cutting Speed of Lathe-Tools. In calculating the number of feet per minute at which a lathe-tool is cutting, measure the perimeter before the cut and after, and multiply the mean of these two measures by the number of rotations per minute.

Centering and Squaring up Connecting-Rods. I go into Squibob's shop and find a man having a connecting-rod to center and square up, laying out a center with a pair of dividers from the square end, driving in a center punch, putting the rod in the lathe, marking the rod on the high side, dropping it on a block, and with a small half-round chisel digging the "center" (Heaven save the mark!) over to the side called for by the chalk-mark, then putting it in the lathe for another chalk-mark, and so on. Then when the rod runs "about" right, he takes a racket and reams a center on which to turn the rod. If the rod is too long he squares the ends to the desired length. Then he cuts off the projecting "centers," and proceeds to re-center the rod.

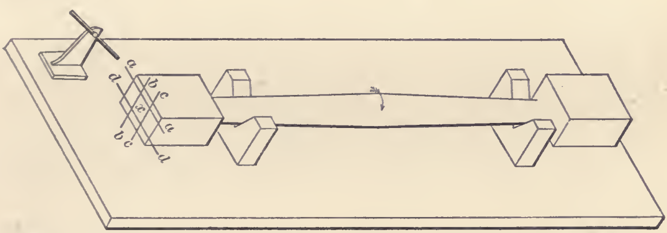


FIG. 52.—SQUARING UP CONNECTING-RODS (DELAMATER WORKS).

Suppose that we try another way, taught me by Superintendent Brown of the Delamater Works. We will say that the rod is about six feet long. Let us put it on a planer-bed or drill bed-plate, or even on a good level board, and place under each neck a V block as shown in Figure 52, so that the rod may be turned over without much changing its position. Now taking a scribe-block, let us draw a line *aa* across the upper side of the square end; then turning the rod one-fourth way around as shown by the arrow, scribe the line *bb*; then again turn and scribe, until the lines *cc*, *dd*, are brought on top. Now we have enclosed in these lines a square the center of which is in the center line of the neck; but this need not be changed in order to make the part run true in the lathe. If the end of the rod is to be finished to $2\frac{1}{2}$ by $4\frac{1}{2}$ inches, we will take the center x, from which to scribe two circles, one $2\frac{1}{2}$ inches in diameter and the other $4\frac{1}{2}$ inches. Then with the scribe-block on the surface-gage, we draw a parallelogram on the rod-end. From this we can tell whether or not the rod-end will clean up to the center x; and if it will not, we can caliper the neck and find how much stock will have to come off; then we can draw the center to suit.

If the rod should be left by the smith say an inch too long, we take a tit-drill and drill in far enough so that it will leave about 1-32 inch to square off in the lathe; then we can remove the tit-drill and use a countersink for the final center on which the rod is to turn. This latter work can be done in a horizontal drill or in an old lathe, by having a drill-chuck fitted to the spindle.

Centering Lathe-Work. Sykes has just put a shaft in a lathe without drilling and countersinking the centers, and the result is that he is doing work which is a trifle out of true, and at the same time he is enlarging the lathe-centers and making it less possible for him to do correct work on other jobs that follow. It is about the same way all over his shop, and the result is that it takes a man who has run any tool in his place to get any sort of work out of that tool. A new man coming in would appear to be a botch although he had come from a good place in one of the best shops in the country, while an old "mossback" who knows how to humor Sykes' lathes and things will get creditable work out of them.

Ballard goes to the other extreme; he puts about a three-quarter-inch hole in the end of a two-inch shaft.

Truing Rubber Rolls. Rubber rolls, such as those used for the feed of various machines, and in leather-splitting machinery, require to be trued up from time to time; and this is best done by grinding. This can be done with a very coarse open emery-wheel, the face of which is kept constantly chalked to prevent what would correspond to pinning in filing.

Turning Vulcanized Fiber. Those who are experimenting with vulcanized fiber bearings, with and without graphite, and with other things in which they find it necessary to turn or bore paper or *papier maché*, often wonder what is the best turning-tool for paper. There is no special best tool. Take what there is, but see that it is sharp and has very little clearance, as the character of the material is such that the tool has a great tendency to dig in and meets very little resistance to prevent it. One principal trouble is that bearing in mind the supposed analogy between paper and wood, as compared with iron, they undertake to turn paper with a wood-turning tool, or with an iron-turning tool run at a wood-turning speed. If they will only run the lathe or boring-mill with boring-tools, at a speed just a trifle in advance of that necessary for cast iron with the same diameter of work, good results should be obtained.

For Key-Seating a Shaft or an Axle while in the lathe, there may be employed two or three ways. One is by rotating a cutter on a vertical arbor, driven by a worm-wheel which is in turn operated by an endless screw on a shaft bearing a grooved pulley driven by a round belt from an overhead shaft; the whole rig being held on the slide-rest.

Another device for doing the same thing is also an attachment to the slide-rest, and consists of a horizontal cotter drill passing through a tool-post and bearing on its outer end a small worm-wheel driven by an endless screw on a shaft having the same kind of a grooved pulley for a round driving-belt.

Turning Shafts. There are three reasons why it is best to turn as little as possible off the outside of wrought-iron or steel shafts. One is that it costs more to take a deep cut than to take a slight one; the second is that the more you take off the greater you waste; and the third, of which very few take special notice, is that the further from the outside you go the poorer the material; this being true both of castings and of forgings or of rolled articles. Turning down shafting is only to make up for imperfections in surface or in diameter. If shafts could be rolled perfectly true in surface and in section, there would not only be no necessity for turning them down, but there would be an actual loss in doing so; it would be paying money and taking time, to lessen the value of the article.

But where shafting has to be turned down, one thing should be done, to start with a sharp tool and with a good enough tool to be able to take the full length of the tool without any perceptible wear of the tool; for every one-hundredth of an inch that the tool wears in length makes the shaft one-fiftieth of an inch greater in diameter, and there is no earthly use in having even a six-inch shaft one-fiftieth of an inch larger at one end than at the other. Another advantage in having the tool sharp is that the sharper it is, other things being equal, the more likely it is to keep on cutting instead of starting to dig in. A sharp tool will trim off the edge of a seam or skim off the edges of a soft place, where a dull one will refuse to do it and wili go fighting for a place to dig in and sulk. That is one of the several reasons why emery and corundum wheels do better work in making calender-rolls and milling-rolls than the best turning-tools in the best of lathes can do, with the best of workmen; and this is one reason why in ordering a steam-engine you should be particular to specify that the crank-pins should be ground after turning.

Counterbalancing Cranks While Turning Them. Much better work is done in turning up cranks if they are counterbalanced while in the lathe; but if this is done when the cranks are in place for working, the balance will not be true by reason of the friction of the lathe having to be overcome. To do this properly, screw steel plugs into the center-pieces and balance the crank while hung on cone-centers; then you may chuck in the lathe in the usual manner. This method will answer for two-throw or three-throw cranks as well as for any other; the balancing-pieces being bolted to the centering-pieces in such positions and amounts as will cause the piece to remain any side up independently.

Boring Tapers. In order to set the swivel on a lathe for boring any degree of taper, measure the diameter of the circular rest-seat, and scribe on a flat surface a circle of that diameter, mark its center and draw a radial line *AB*, Figure 53; mark off a distance *AB* equal to the diameter of the small end of the hole to be bored; draw the line *AG* at right angles to *AB*, and *GD* parallel to *AB*, of a length equal to the diameter of the large end of the hole. Connecting *DB*, the distance *EF* on the circumference of the circle between

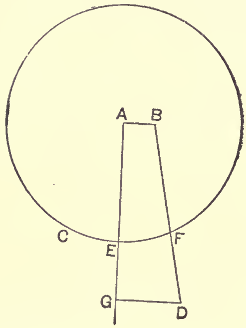


FIG. 53.—CALCULATING ADJUSTMENT OF SLIDE-REST.

where *AG* and *BD* cut it will be the amount that the rest must be swiveled to cut the desired taper. Figure 54 shows a good form of rest for such work.

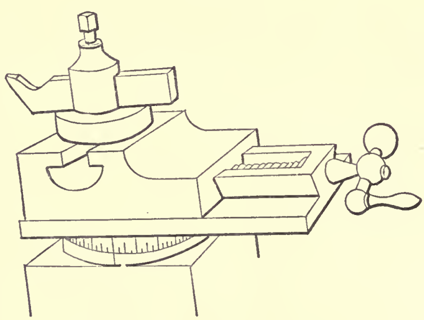


FIG. 54.—SWIVEL REST FOR BORING TAPERS.

Nicking Stock for Breaking Off. I saw a man, who was old enough to know better, "nicking" a piece of stock with a half-round tool. This requires a much deeper nick to effect breakage at the desired point than where a V tool is used. Where a square-nosed tool is used, there is also required a deeper nick than with the V tool, and the break will be apt to occur at one of the abrupt angles instead of in the middle of the groove.

Metric-Pitch Screws. You want to cut screws with a metric pitch, for that Persian job, and don't know just how to make your lathe "walk Spanish"? Few things easier. Make a "translating gear" having on one stud two wheels, one with fifty teeth and the other with 157. Their ratio is 1 to 0.3937, which is about as close as you will be liable to get anything; for the lathes that work to fine decimal points are few, and the men who will do it on them just as few.

Turning a Cube in a Lathe. While the lathe, considered as a tool for turning objects perfectly round, is not a success, yet it may be made to do a great many other things well. For instance, one can turn a cube in it. To do this from a cylinder, get one that is as long as it is thick, or to put it more technically, the diameter of which is equal to its hight. Describe a square on one of its circular faces or ends. Find two points on its convex side, at just half its length from each end, and exactly opposite each other. Chuck the cylinder about the diameter joining these two lines, and face off a slab down to one of the four lines representing the side of the cube that is to be. Chuck it again at the quarter-points, removing a slab, then reverse and take off a fourth slab, and the cube is left.

To cut a cube of a given size from a cylinder, there must be used one having a diameter equal to the diagonal of one of the flat sides of the cube. To turn a cube from a sphere, the latter must have a diameter equal to the longest diagonal of the cube. Thus, to get a one-inch cube we must have a cylinder 1.414 inches in diameter, or a sphere 1.678 inches.

Various Uses of the Lathe. One use to which it may be put in a manufacturing business (as distinguished from a jobbing business where no two successive pieces of work are alike) is to act as a rotary shears for cutting off wire and small rods. In order to do this, bolt on the face-plate a hardened steel plate or block having one edge so placed as to cut the radius of the face-plate at an angle; then provide for the tool-post a block bored or drilled exactly to fit the wire or rod, and so placed that the cutting-plate or block bolted on the face-plate shall just clear it in rotating; also that when so placed the bore-hole shall be at right angles with the face of the face-plate. Then every time the face-plate makes a rotation, it will cut off from the wire (if the latter is kept pushed up against it) a piece as long as the distance of projection of the cutting-plate which is bolted to it. If shorter lengths are desired, they may be arranged for without making a thinner block or plate, by fastening a thickness-piece on the face-plate in advance of the cutting edge of the plate or block, letting it extend far enough in advance to make it easy to let the end of the wire or rod bear on it without getting snagged by its advancing edge.

Boring Holes in the Lathe should never be done before the work has been faced off. There are two reasons for this; the bore would not be true if the facing was left to the last, and the scale would dull the boring-tool.

Starting Reamer. To get a hole the right size for a hand reamer to follow, such a machine reamer as is shown in Figure 55 will do well. It may follow an ordinary twist drill; if the drill is forced through straight there will be but little work for the machine reamer to do, and still less for the hand reamer. It can be about four-one-thousandths smaller than the hand reamer, with a slight taper; and say about two-thousandths smaller at the back than at the cutting

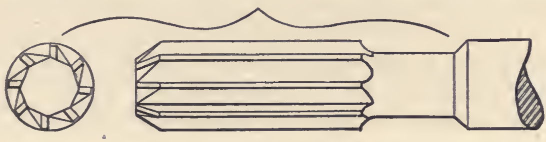


FIG. 55.—STARTING REAMER.

edges. For iron and steel its teeth need not be backed off lengthwise as in a hand reamer, as it cuts only on the beveled end. For brass it must be backed off the whole length to keep it from binding.

Stepped Reamer for Tapers. Tapered holes may be reamed true more readily by roughing them out first with a stepped reamer, such as is shown in Figure 56, the ends of the steps, *A*, *B*, *C*, being in a straight line

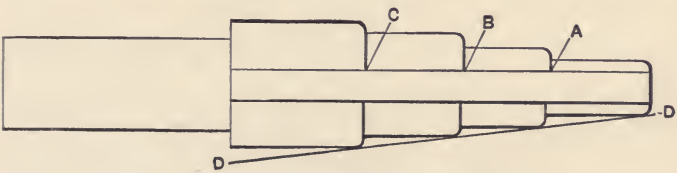


FIG. 56.—STEPPED REAMER FOR TAPERS.

DD which has the requisite degree of taper; although the diameters must be a trifle less than the required finished diameter, so that the finishing reamer with an ordinary straight taper may give the right size exactly. Each step should have about one-one-hundredth inch clearance, not quite meeting the flute of its cutting-side. In this tool each step has a guide for its cutting-edge. The flute may be straight or spiral, and if the taper is very slight a left-hand spiral will be necessary to keep the tool from running forward and taking too deep a cut; but if there is much taper it is better to have a right-hand spiral.

Fine Taper Reaming. Almost any one can do good parallel reaming, but it takes a mechanic to ream taper, especially when the diameter and degree of taper must be absolute. Those who have tried it and found on their first attempts that there were left lines running along the bore, just where each tooth or lip stopped, will admit that to ream taper is a fine art. The Hancock Inspirator Co. manufactures a boiler-feeder which must be made just right or it will not give proper service, and this must be done on a commercial basis so that the device may be sold in competition with others, and at a profit. The reamer which is used in its shops for fine taper work has a section almost like a circular saw with very large raking teeth, comparatively few in number. In fact the lips are so fluted as to have no backs at all; and then the backs put on by grinding for about one-sixty-fourth inch after the hardening has been done, and last giving the clearance by an oil-stone. The greatest possible odd number of teeth is used, and the flutes are parallel with the axis. Their work is very light, just to give a slight scrape.

Adjustable vs. Standard Reamers. In many shops there are adjustable reamers capable of very fine range of variations at will; but the Pratt & Whitney Co. finds that a reamer of fixed diameter properly relieved and made of good tool steel, carefully hardened and tempered, will in the ordinary operations of machine-shop practice maintain its standard qualities long after the more adjustable reamer is laid aside. In this Company's shops an ordinary non-adjustable chuck reamer reamed to gage over 14,000 holes two inches deep in cast iron without perceptible change of size, using simply an upright drill for the work.

An Adjustable Reamer for small work is shown in Figure 57; it comes from the "land of steady habits." The cutters *A* and *B* are adjustable along their slots

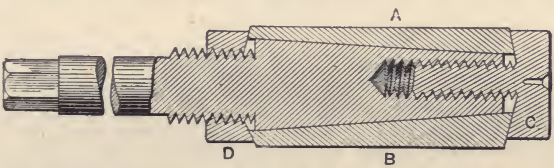


FIG. 57.—ADJUSTABLE REAMER FOR SMALL WORK.

by the screw *C* and the nut *D*. For larger work (say up to three or four inches) the form shown in Figure

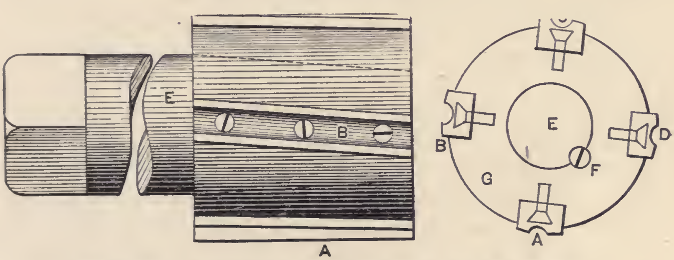


FIG. 58.—ADJUSTABLE REAMER FOR LARGE WORK.

58 is good. The cutters *AB*, *CD* have two cutting-edges each, and are held by screws set at an angle to

the arbor-axis and are irregularly spaced. As they wear they are set out by paper.

Reaming Brass. After reaming brass be careful to have the reamers not only sharper than for working in iron or steel, but with more clearness. In some shops, however, there is but one set of reamers for all kinds of work in every kind of metal. In such cases solid reamers will not answer; they must be adjustable, and there must come with them a set of plug and ring gages by which they may be adjusted and with which the work itself may be tried. These gages come in handy also for caliper-setting when turning on the lathe.

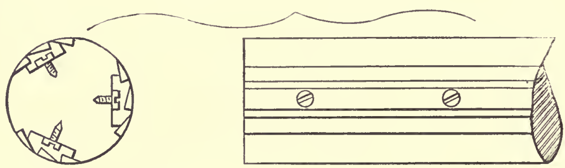


FIG. 59.—REAMER FOR BRASS.

Figure 59 shows an adjustable reamer having three equally spaced slots milled or planed in its body, and having in these rectangular pieces of steel, held by small machine-screws; then the whole turned down, leaving metal for grinding and hardening. Next the blade bottoms are ground straight, and the blades screwed to their place and ground to within two-thousandths of the finished size, next oil-stoned to size. To get good results in oil-stoning, use the slips as you would a file; leave the cutting edges of the teeth the highest. This reamer may be brought up to size after wear, by packing strips of tissue paper. Under three-fourths-inch this style could not be used, as it would be too light and would spring, by reason of the slots weakening the stock.

Reamed Holes "Just a Trifle too Small." If mechanics worked as "fine" as they should, the trouble of finding a reamed hole "just a trifle too small" need not occur. As it is, it does happen, several times too often, and the main thing is not to inveigh against its happening, but to remedy it. Some years ago Mr. Almond patented a reamer for taking say half-a-thousandth of an inch from the inside of a hole, for instance, three or four inches in diameter in cast iron. There are teeth cut just as in an ordinary reamer, but then there is a slot in which slides a cutting-blade which may be made, by both it and the slot being tapered, to project any desired amount beyond the rest. By this means a very slight amount of cut may be made; the other teeth acting practically only as guides.

Holding Reamers while Marking them may be done by the rig shown in Figure 60. There is an inner

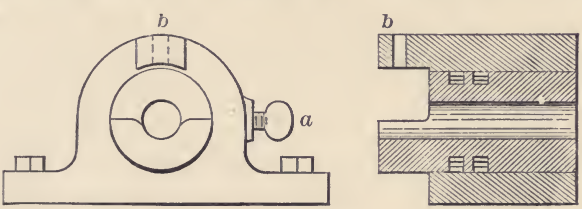


FIG 60.—HOLDING REAMERS WHILE MARKING THEM. (HARRINGTONS.)

sleeve which is free to turn, but cannot move endwise by reason of the plug fitting in either of the grooves shown in the sectional view. This inner sleeve holds the reamer or tap or whatever it is, the first letter-punch is introduced in the opening, adjusted and struck with the hammer ; then the sleeve is turned the proper distance for the next letter, the second punch is introduced, and so on ; the fact being that all the letters are in line around the shank. Where there are two lines of lettering, the plug may be pulled out, the sleeve moved endwise the requisite distance, and the second circumferential line of marking done. Edwin Harrington & Son use this.

Turret-Tool Lubricator. Instead of ordinary soap and water which you are now using, try whale-oil soap, which you will find better ; but still better yet, use good lard oil and plenty of it, and after use extract the chips therefrom (or extract it from the chips, whichever way you please to call it) by a filter, so as to use it again. Those who have enough of it to warrant may use a centrifugal extractor ; but for ordinary purposes and small quantities a good filter does as well.

Disposing of Turnings. Just what to do with the turnings and how to handle them most readily is a question which often agitates large establishments. They have a certain market value, where they are not disposed of in the shops that make them ; but if they are mixed, that is, brass and iron, or even steel and iron together, they are neither usable nor salable. In the Baldwin Locomotive Works, where there are runways all over the concern, all the kinds of turnings, cast iron, wrought iron, steel, and brass, are kept separate to start with ; this being more readily done here, where piece-work is the rule (clear down to labor), than where the other system prevails. The accumulations of each day are brought over in cars, each kind separately, to the second story of the boiler-house, where there are shoots to convey them from hoppers, marked plainly with the name of each kind of turning, to cars or wagons on the street level. This system saves time in handling the material, and enables their delivery from all over the shops (covering several city blocks) to a certain point, all of a kind together.

Quick-Return Planers. Life is short—and while it is just about as long now as it was in the days of our forefathers—perhaps a trifle longer owing to the better care that we can take of both weak and strong—we realize its brevity more vividly than our ancestors did, and we want to do more work in a given time in manufacturing and to do the same work in less time in repairing. This is shown better, perhaps, on the average metal-planer than on any other machine-tool. Once a return speed of two to one was considered ample ratio; then three to one was thought rushing things; but now few respectable builders will give less than five to one, and many shops demand seven to one where the work is not so heavy as to make the return from light cuts at high speed a cause of too much jar.

Open-Side Planers. There is a large increase in the use of open-side planers and milling-machines, and there will be a still larger demand for them when the makers study rather further the laws of strains on framing, so as to stiffen their machines, without increasing their weight. Many machines would be more convenient if there were two tables, so that with certain classes of work one piece could be adjusting on one table while another was being worked on the other table.

Overfeed of Planers may be rendered harmless by cutting off the threads at each end of the feed-screw, so that if the saddle feeds to the end of the screw the rest may not be carried against the end of the cross-slide.

Taking up Apron-Pivot Wear. When the apron of a planer or a shaper gets loose on its pivot, so that it jumps on entering and on leaving the cut, it is time to remedy it. This may be done by giving the apron a bevel projection on the back lower edge, fitting under a corresponding chamfer on the head, so that it cannot lift when the tool strikes the work, nor can it wobble sidewise.

Pit Planer Lead-Screw. In the Mennig shops in Brussels, Belgium, there is a big pit planer which has one very nice feature about its lead-screw. There is at one end a pair of collars which take the thrust in both directions and transmit it through a series of hardened steel balls to the bearing proper, thereby relieving the machine of very much of the strain to which it would otherwise be submitted.

For Holding Work on a Planer-Bed many ways are employed ; some classes of work will be more readily held by one fastening and some by others. Where there are many pieces of the same kind made at once, there should usually be some certain and special provision made for holding and releasing promptly. One way for holding narrow and thin pieces is to let the end rest against the ordinary "snub" stuck through one of the holes in the planer-bed; then at a few inches from each side to run in rows of snubs which have drilled and tapped in them about thirty degrees from the planer-bed and at right angles to its width, steel bolts having cone-center holes made in their lower ends. Between these bolts and the work to be held there are placed short pieces of steel rod with each end turned to about a sixty-degree cone. One end of each of these steel pieces digs into the side of the work, just above the planer-bed, the other end fits into the centers in the ends of the bolts; the bolts and the steel pieces of course coming axially in line in order to get a good grip on the work, and to prevent the steel pieces being knocked out. The end snub takes the lengthwise horizontal thrust of the tool, and the side pieces resist both the lateral and the lifting tendency, so that greedy cuts can be made.

Supplementary Planer-Tables. In order to permit a planer to take in work of greater width than the regular table, you may add supplementary tables fitted with T-slots and bolt-holes; these lying across the table or bed proper, to which they are held by set-screws, passing through lugs extending down from the supplementary tables; the distance between the inside surfaces of these lugs being just the width of the planer bed. Hewes & Phillips have these. They may be used in other ways, as for supporting frames, the ends and the sides of which are to be planed, and which may be held to one of these supplementary tables bolted to an angle-plate. They may also be used, end on, as butting-pieces for the ends of long frames which are to be planed on their edges.

A Swiveling Supplementary Planer-Table is for many kinds of work, as for link-planing, an advantage; it may very readily be applied to a plain table clamped across the regular planer-table.

Planer-Chucks. See to it that the bottoms of your planer-chucks are perfectly true, and that you have a number of perfectly parallel strips as long as the chuck-jaws; then you can put all kinds of work in the chuck in a very short time, and at exactly the right depth.

Shaper Chucks are, as ordinarily made, very inconvenient for working the ends of round work. If, however, they are made with the jaws projecting beyond the sides, the piece may be very readily handled.

Bunter-Chucks for Planers. Many good planer-hands seldom use a vise if they can get out of it; setting the work directly on the planer-table and holding

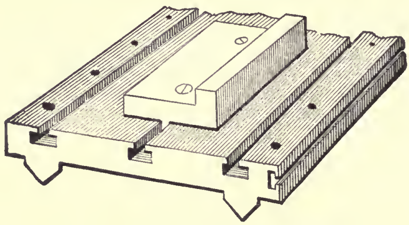


FIG. 61.—BUNTER CHUCK.

it by "bunters," straps, etc. One of the best forms of bunter-chucks is shown in Figure 61, being made in 12-inch to 18-inch sections so that according to the

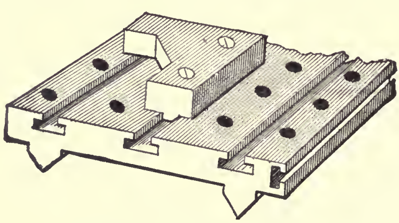


FIG. 62.—BUNTER CHUCK.

length of work being handled, one or more parts may be used in line. One side is made higher than the other, so that it may be used for work of different hights. The heads of the holding-screws are let into countersunk holes and slotted so that they may be turned by a strong screw-driver; they enter nuts in the T-slot of the table.

Where it is necessary to do a variety of small work on a medium-sized machine the form shown in Figure

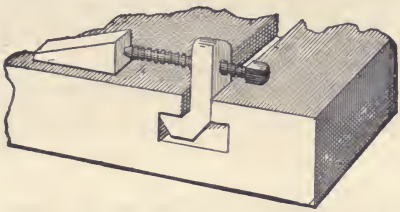


FIG. 63.—SHOWING USE OF BUNTER SCREW.

62 is useful; two faces being at right angles to each other and vertical to the planer-table, thus saving much time in shifting fixtures, etc.

Where by reason of the arrangement of holes in the planer-table the usual studs cannot be put where they would be desirable, especially on small work, the bunter screw may be used in a block as shown in Figure 63, which may be put in place and taken from the slot within frames or beds, without disturbing them or adjoining fixtures.

These wrinkles come from Springfield, Mass.

Setting Machine-Beds on Planers. To do this for the first planing so that there shall be no twist nor sag, and so that after planing the bed may be turned over on its newly-planed side and bear perfectly on the planer-table, is not always accomplished; and where it is done it is not always done so easily as by the following method:

Assume six points on its under surface; two, as A, B, in the center of the ends, and four, as *C*, *D*, *E*, *F*, at points on its sides near the ends.

Provide six metal setting-wedges of equal dimensions. Raise the bed on two of them, placed at the end points *A*, *B*; scribe a line on the upper surface of each, to mark where the end face of the bed comes, when the bed is level. Then insert wedges *C*, *D*, *E*, *F*, without driving; scribe lines thereon coincident

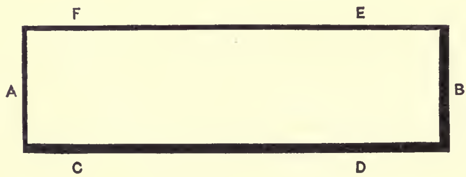


FIG. 64.—SETTING MACHINE-BEDS ON PLANERS.

with the side of the bed; next drive *C* and *F*, taking the weight from *A*; scribe lines on *A*, and scribe on each of these two a second line; do the same with *D* and *E* as with *C* and *F*; then take out *C*, *D*, *E*, and *F*, and scribe midway between the two lines on each, a third line; drive all four of these side wedges up to the middle line on each.

Planing Connecting-Rods. You don't seem to have quite struck the way to get these connecting-rods true in the way of alignment of side-faces and edges. Get a straight-edge longer than the entire rod; apply it to one of the cheeks of the big end and note the distance between it and the cheek of the small end. Do the same thing with the other side; then you will see whether or not the alignment is right. If the distances are unequal, one of the stub-ends is to one side of the center of the rod. Then apply the straight-edge to the wide face of the small end and let it lie on the narrow edge of the large end, scribing a line to show the amount by which the large end projects each side beyond the small one. Do the same thing with the other side. The two distances of offset should be equal. Then take two "winding strips" and lay them parallel, one on each wide face on one side of the rod; sight them, and if they do not come in the same plane the faces are out of plane with each other.

Hollow Planing. Once in a while there is a demand for a piece of hollow planing, as in locomotive connecting-rods; not radial planing, in which the curve is across the line of action of the tool, but hollow-planing in which the cut is required to be deeper at the middle of its length than towards the ends, the depth of cut lessening gradually and regularly from the center both ways. It is a more simple thing to do—when you know how; and all the "know how" consists in blocking the piece up in the center so as to spring it vertically as much as the offset or rise of the required curvature, and then planing straight. On freeing the piece it will resume its straight outline and have the proper face-curve.

This lengthwise curved planing may if desired be combined with radial planing, so as to give the face curvature in both directions. This method of working is of course only adapted to pieces which are long enough in comparison with their thickness, to be sprung on the planer-bed.

Planing Dead Straight. You cannot plane anything dead straight, nor can you turn anything perfectly round. You must resort to grinding or scraping, or both. You might as well give it up before you commence, if you have any ideas of turning round or planing flat. It is not in the nature of even the best of machine-tools to do it.

Planing Large Cast-Iron Plates. As long as you go on in the way that you are, in planing up those big iron plates, you will not get one of them straight. You cast them about six feet by four, and an inch and a half thick, and then you plane off a thirty-second, and scrape them, and wonder that they are not flat. They mean to be flat, but they can't. You have taken off the skin from one side and that makes them curl; and all the scraping and filing that you can put on them in two days will not make them be straight and stay straight. If you will take a thirty-second off what is to be the finished side and then one-sixteenth off the back and then turn and take another one-thirty-second off the face, you will find them in about the same condition of tension on both sides, and they will stay reasonably flat and straight; then all that you have to do with your scraper is to correct any high spots that may exist by reason of the metal having been hard in spots and resisting the planer-tools. R. Hoe & Co. do this. You will save by doing intelligently by cheap labor on the planer, what you are now paying a high-priced man to do with infinite pains and skill against the heaviest odds. That man is a good bench-hand, and is doing his share of it with a skill which you will find to be very rare in these days; but it is not his place (as he sees things) to tell you how you may dispense with about seven-eighths of his work and get the plates done in half the time that it now takes.

By such gradual approach to finishing dimensions as I have mentioned, coupled with proper bolting down to the planer-bed, the largest plates may be made as perfectly plane as is demanded. They should be tried, after planing, with a slightly bellying file, held in a special holder; and then given final finish as to surface, by the scraper. In such work good surface-plates should be used; and these should be tested with each other and with a standard, which latter should never be used except for purposes of comparison.

In Packing up Work on a Planer, instead of using blocks of this, that and the other size, and with thick

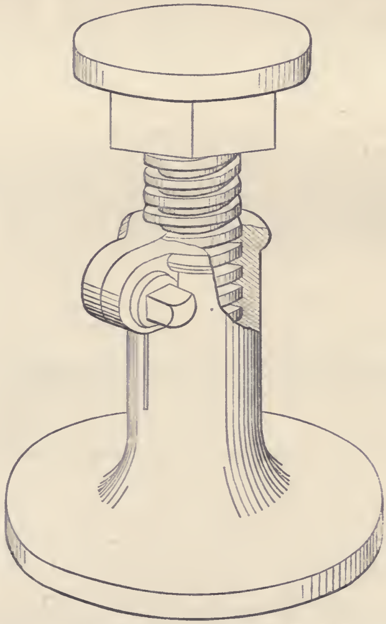
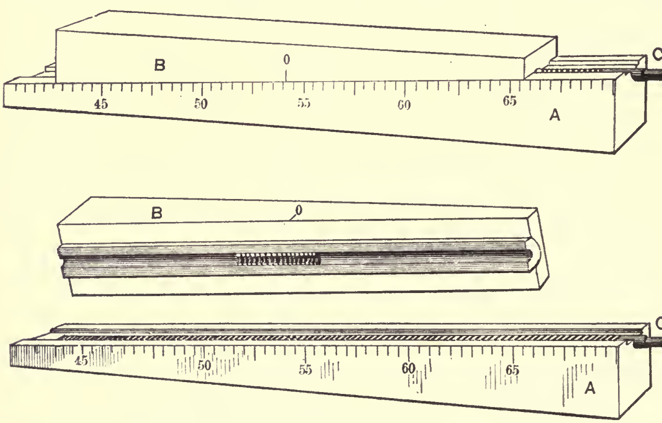


FIG. 65.—PACKING UP WORK ON A PLANER.

and thin pieces of this, that and the other stuff, why not make yourself some short jack-screws consisting of a disk or flat-footed piece having in the center an upright bored out and threaded on the inside, and in which is a stout screw with a big head? Such a rig as that will enable you to set pieces at any desired height, and always to get the same height; also to get both ends or sides of the same piece at the same height. If you have a lug cast on one side of the post, and split the lug and the post you can use a pinching-screw to prevent any possible loss of adjustment.

Adjustable Parallels. Wedges and "shims" (by the way this latter is a New England word and not much known south of New York) are sometimes



FIGS. 66 AND 67.—ADJUSTABLE PARALLELS.

very inconvenient in setting planer-work; and their use may be very well superseded by adjustable parallels, which may be found in some of the Springfield shops.

One form of these adjustable parallels by which very accurate setting may be effected is shown in Figures 66 and 67. The two slips *A* and *B* are tongued and grooved together, but along the tongue and the groove is a semicircular groove which is threaded part way along to receive a long adjusting-screw *C* by which *B*, which is the shorter of the two, may be given any desired amount of travel along *A*. The pitch of *C* and the angle of the pieces *A* and *B* being known, it is very easy to figure out how much advance one turn of *C* will give to *B*; and *A* may be graduated on the edge with reference to this, so that the position of a zero-mark on *B* may indicate the total height of both pieces.

Adjustable parallels are by no means new, but were invented by no less a person than James Watt, who by the way, invented also the letter-copying roller press and screw press. Only in the original form there was no screw, merely a series of notches into which a pin might be dropped.

Planer Gage-Blocks. A good way of getting the proper height of a planer-tool is to have a lot of small cast-iron blocks planed and lapped to size and stamped on each face with the height of that face. There are many cases where such a set of blocks could be employed, where neither scales, calipers nor surface-gages could be used with convenience. Blocks and plates running 1-32, 1-16, 3-32, $\frac{1}{8}$, 5-16, and $\frac{5}{8}$ inch will give all sizes up to $1\frac{1}{4}$ inches in thirty-seconds of an inch ; blocks of 5-100, one, two, three and four-tenths inches will measure all sizes up to one inch in both tenths and half-tenths. Of course, in the larger sizes, each block may have three separate dimensions stamped, but the thin plates cannot so well be used in combination; that is, a plate four inches by three and only 1-16 inch thick could not be well used with one two by one by 1-32, to show 3 1-16 or 4 1-32 inches; but one 1 by $\frac{3}{4}$ by $\frac{1}{2}$ inches could be well used with one 11-16 by 9-16 by 7-16 to show 1 11-16, 1 9-16, 1 7-16, 1 5-16, 1 3-16, 1 1-16, and 15-16 inches in height.

Cutting Internal Gears on a Planer. This may be done by casting the gear-blank with a spider attached, which may be driven on an ordinary mandrel, and bending the tool so as to cut on the side and also to stand out in front. Then the head-stock being bent down so as not to raise the tool when it is drawn back, the teeth may be nicely cut; after which the rim may be separated from the spider.

Cutting Gear-Wheels on the Slotter. To cut a gear-wheel of an unusual size, pitch, or tooth shape, sometimes bothers the average shop, which is equipped only with the standard cutters such as are furnished by two or three firms that have had the good sense to make their system of tooth-curves uniform, so that every spur-wheel of the same pitch will mesh with every other made by the same set of cutters. Then again some shops have no large milling-machines; some have none at all; so even if they had the cutters they might not be able to use them. Again, it does not always pay to get a set of cutters for a job which may never have to be duplicated.

For such work it is very often perfectly feasible to use a slotting-machine with a cutter of the shape of the tooth-space. The wheel or rack blank is first carefully graduated into the requisite number of divisions (if there is no graduated chuck on the slotter); then is bolted fast to the slotter-bed or table and a scribe-mark made on the latter to correspond with one of the division-marks on the edge of the wheel-blank. Then the tool is set to work until a tooth-space is cut; the wheel is then turned or the rack slid along until the second division-mark on its periphery or edge is in exact line with the scribe-mark on the slotter-bed, a second space cut, and so on.

It is well not to do all the work with one tool, but to have a rough cut taken for each space with a tool which will make the approximate outline, and then to finish off with one filed or ground exactly to the requisite form.

For this class of work, as for many others, chilled cast-iron tools will be found very desirable, as they keep their shape and take greedy cuts, and may be made of a special outline such as that required for tooth-space cutting, more quickly and cheaply than by forging.

Over-accuracy. At the Centennial there was a platform scale exhibited presided over by an attendant who weighed each person who wished it, and gave him or her a card on which his weight in pounds and ounces (and I am not sure but it was also in fractions of an ounce) was recorded as having been taken on the specified day, on the celebrated Blank & Co's standard scales.

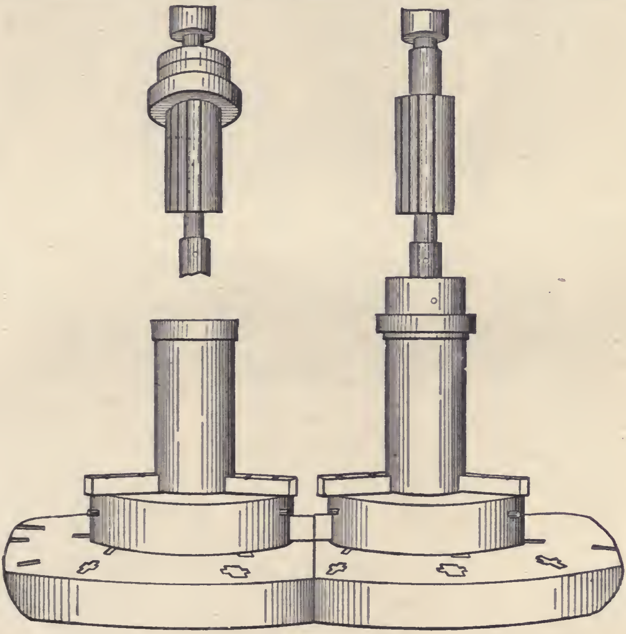
Now it happened that the scale-beam was notched only to quarter pounds. Still, it made the folks happy, and the matter seems to me now, as it did then, humorous, as an instance of overaccuracy. But it is not the only one across which I have come for a long time. For instance, in a gun-shop (using "gun" in the sense of cannon) the boring is conducted very much like a religious rite, in the attempt to get absolute accuracy in diameter and absolute straightness of bore. There are about as many steady-rests as the law allows, in order to obviate the possibility of any lack of straightness in the finished bore. But when the piece is mounted on its trunnions, its long tube projects out unsupported, and the muzzle droops, as a matter of course.

The only way to get a gun-bore straight is to rotate the piece itself instead of the tool.

In Boring Cylinders it is better to use three cutters than one or than two. With one cutter there is spring to the bar. With two the bar is less well supported than with three. One cutter will cause the hole to be smaller in the middle than at the ends of the cylinders; and the surface of the metal will be rougher in the middle than at the ends of the cylinder.

Boring Large Holes in a Cored Casting, where accuracy is required, it is not usually an easy matter; yet in one shop at least (T. R. Almond's in Brooklyn) there is an original method of doing good work and plenty of it, which I am glad to show you.

The work, which is a sleeve, is held in a three-jawed chuck, gripped "short;" a wooden disc being placed between it and the chuck to keep from cramping; then a guide or sleeve, bored to fit the work and also the reamer, is placed over both the latter and the reamer set to cutting. The cutters are ground perfectly square on the points; the guide is about one one-thousandth inch larger than the reamer; the hole bored being of the size of the hole in the sleeve instead of that of the reamer by reason of the tool having a tendency to "wander" within the limits of the sleeve. The guide fits easily over the work and is firmly held until the cutter has fairly entered (say 1-16 inch) serving both to center the cutter and to steady the work. After once starting, the sleeve is raised (as shown in the second illustration), a small pin holding it above the upper cutter; the two holes



FIGS. 68 AND 69.—BORING LARGE HOLES IN A CORED CASTING. (ALMOND.)

are then finished at one cut and are found to be exactly in line. The bottom of the large hole is roughed out in the lathe before boring, to save the cutter; the extra work being paid for in extra life of the tools

Boring and Reaming in Two Metals. To bore a hole in a piece, one side of which is of a different metal from the other, is difficult, especially when the circumferences of the two pieces are about equal. The softer side gets the larger diameter of hole, and reaming becomes necessary. This may be accomplished by a dish-faced rose bit such as is shown in Figure 70, the dish having an angle of 10° or 15° with the end, and being cut into seven teeth. Bore the job with a tool in the lathe tool-post until the hole is only a trifle too large on the softer side; then chamfer the edge of the hole on the harder side with a file, up to the proper size, and go in with the dished rose bit and plenty of oil.

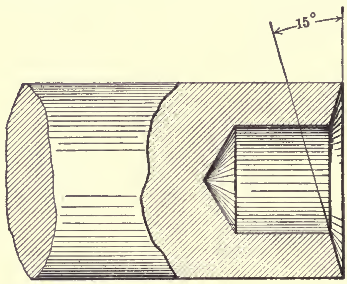
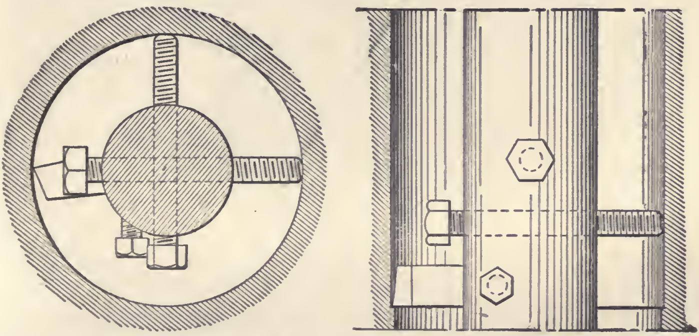


FIG. 70.—DISH-FACED ROSE BIT FOR REAMING TRUE HOLES IN TWO METALS.

For Boring Long, Deep Holes that do not go clear through the pieces so as to permit of using a boring-bar, use a tool having right back of it a set-screw which may be run out so as to touch the opposite side of the bore from the one the tool is working on; and have half-way between these two, so as to touch the circumference of the bore-hole ninety degrees from the tool and also ninety degrees from the first screw, a similar screw which may be adjusted so that the tool will be held central and the hole kept straight. If the job be such as to permit the hole being bored vertically, there will be no trouble about getting out



FIGS. 71 AND 72.—FOR BORING LONG DEEP HOLES.

the borings or having them crowd under either of the set-screws; but if it must be a horizontal job, the tool must be rigged so that one of the screws shall be at the top, and the other at one side, the tool being on the other side.

A Guide-Box for a Boring-Bar, arranged so as to be adapted to bars of various sizes, is shown in Figure 73. It is used on the bottom plate of a drill-press, below the spindle. It is fitted so as to exclude dirt and chips, and consists of two bushings, one within the other, and both contained in an outside box or shell *F*. The outside bushing is plain and kept stationary by a set-screw at *G*; there is therefore no wear on the shell *F*. The inner bushings are bored to suit different sizes of bar. They have feather keys and are kept from lifting out by a set-screw running in a groove in the bushing. This inside bushing is flanged on top, covering over the inside bush and

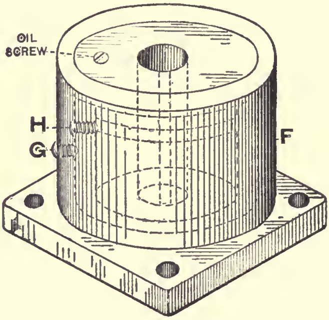


FIG. 73.—GUIDE-BOX FOR BORING-BAR. (RIEHLÉS.)

joints, and both rest on a shoulder corresponding with the bottom flange of the outside shell. This apparatus has proved very satisfactory to the Riehlé Bros., in whose shops it originated.

Boring-Bar. At the Atlantic Works, Philadelphia, I found a good boring-bar consisting of a weldless steel tube mortised for the cutters; one end having a shank for the machine, the other end threaded

FIG. 74.—BORING-BAR. (ATLANTIC WORKS.)

inside for a lengthwise screw, as shown in the illustration. Between the mortises are short lengths of steel rod, as long as between the mortises. The cutters have no taper; they are held by jamming in the central line of the bar, by the set-screw and the rods. This rig cannot spring as is often the case where taper cutters are jammed by wedges. A tube 15-16 inch outside diameter bores an inch hole. Once closed up, the inner rods are never removed.

Boring-Bar Standards. In Mr. Geo. C. Howard's shops in Philadelphia, they have a regular set of standards for the slots, cutters, and keys for boring-bars. These I give, as many shops have none, and it is better and cheaper to have them:

Slot or mortise, 3-16 the bar diameter.

Slot-length, the bar-diameter.

Cutter-width, 13-16 the bar-diameter.

Small end of the key, 3-16 square the diameter of the bar.

Taper end of the key, one inch per foot.

Key-length, the same as the bar-diameter.

Thus for a one-inch bar the slot is 3-16 by 1 inch; the cutter 13-16 by 13-16 inch.

Drill-Racks on Drill-Presses. A great convenience about a radial drill-press is a rack for the drills, fastened on the sleeve to which the radial arm is attached. A drill rack in this position is always in reach of the workman, and the drills are kept in better condition in this way than if laid down to get knocked against each other or against other things—to say nothing of their getting scattered or lost.

Drill-Press Heads. A convenient way of having the sliding heads of drill-presses secured to the column is by a lever and eccentric, tightening a bolt fitting into a T slot in the face of the column—thus doing away with the necessity of a wrench for bolt-tightening.

Increasing the Span of a Drill-Press Arm, as for drilling or boring holes at a great distance from the edge of a plate or table, may be done by such a device as is shown in Figure 75. In this case the sleeve *C* is slipped over the rack-spindle and clamped fast, while *D* is fitted and screwed tight to the driving-spindle.

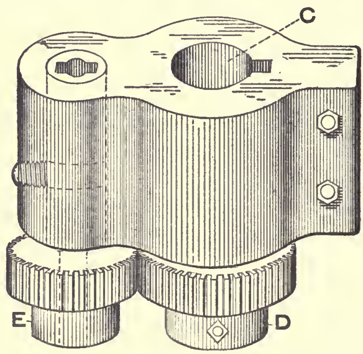


FIG. 75.—INCREASING SPAN OF DRILL PRESS ARM. (RIEHLÉS.)

By gearing this to the drill-socket spindle *E*, the rotation is extended to a distance equal to the distance between socket-centers. In this case it is necessary either to cross the belt of the press, or to use left-handed drills and boring-cutters. This is from the practice of Riehlé Bros.

For Making Hand-Holes and man-holes in a hurry, as for special tank work, there is often a good deal of delay by marking out the outline of a more or less perfect ellipse (misscalled an oval) and then, having drilled from forty to seventy-five holes all around it, chipping out the metal within the drill-holes. The same general effect can be done much more quickly and more cheaply, by slotting the end of a drill-spindle and passing through it a turned-down tool, setting this so as to cut a circle of say three inches diameter, and cutting out two such holes five inches apart, the line joining their diameters being in the line of the longest axis of the desired man-hole. Then changing the setting of the tool so as to cut out a circle five inches in diameter, and, centering this half way between the centers of the other circles, cutting out a third hole, the projecting metal on each side may be chipped away in a gentle curve that is tangent to the circular arcs, and the resulting hole will be near enough to shape and smooth enough in outline for all practical purposes.

A similar principle may be applied to laying out the plate, with three circles of two radii, whether the plate is to be run inside and held by an arch-piece to a single central bolt, or by bolts all around this rim.

Drill-Chucks. One form of drill-chuck which is not patented and is recommended by many, is for straight-shanked drills, having one flat side parallel with the axis. The hole in the socket is punched hot and turned true with the hole. A thumb-screw holds the drill in place. Another way is with a flat side to the drill, tapering about one-eighth inch per inch ; and the socket has a hole by which the drill may be forced out by a drift.

Drill-Chucks that screw to the spindles usually take more time and make more trouble in screwing them on and off than they should. This trouble may be lessened by dividing the thread part on the spindles into four equal parts, cutting away half the thread on two opposite quarters, then doing the same thing with the thread in the chuck. This will permit the chuck to be put on and made fast by a single quarter-turn.

Facing Large Work in the Drill-Press. A cross-slide attachment for doing this is shown in Figure 76, which is taken from the practice of the Riehlé Bros. Testing Machine Co. It is attached to the

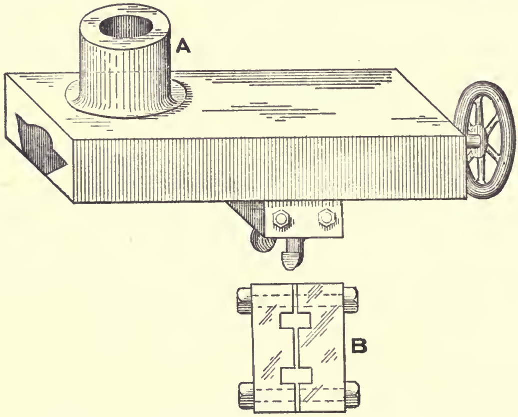


FIG. 76 – FACING LARGE WORK ON THE DRILL PRESS ARM. (RIEHLÈS.)

drill-press spindle at the hub-socket *A*. A hand-wheel, or spur-wheel, can be used for feeding the tool-holder *B* across the slide; the tools, of square steel, being readily clamped in the square sockets.

Ball-Handle Drilling Fixture. A ball crank-handle such as is used on a lathe slide-rest is not a very convenient thing to drill; and when there are several of them to be drilled you might find it well to try Mr. Peter Schellenbeck's way. He makes a frame *A* long enough to take in the ball-handle and having two center-point set-screws *BB* on which he suspends the ball-handle itself. Then he makes a thimble *c*, threaded outside and bored through the center to correspond with a hole through the small ball of the handle. A hole is tapped through the frame *A*, and threaded to take in the thimble *e*. By adjusting the screws *BB*, the ball *d* can be brought exactly central with the thimble *e* when the latter is in place. There is another thimble *F*, also coned out at one end to take in a ball, and also threaded outside; the slotted hole through the frame *A* is larger than the diameter

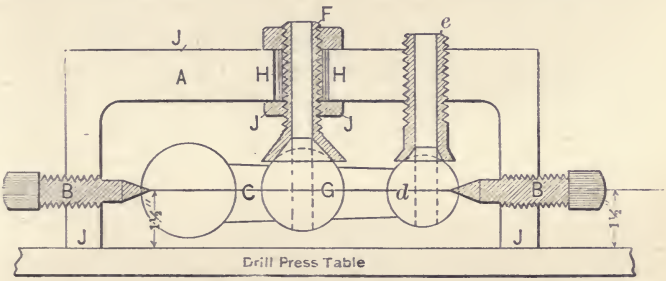


FIG. 77.—HANDLE-DRILLING FIXTURE. (SCHELLENBECK.)

of *F* to enable it to slip through and also have some motion lengthwise of A; and jam nuts *J* are used on *F* to hold it in place when it is centered on the middle ball *G*. The frame *A* is planed at such points *JJ* as will enable the drilling to be done accurately.

Clamping Flanges, etc. It often happens that it is desirable to clamp two flanges or other pieces together temporarily, as while drilling bolt-holes marking the position of bolt-hole centers in one piece to correspond with those in the other, etc. To do this there may be used any one of a number of devices, some of which are here shown.

The first, illustrated in Figure 78, consists of a pair of pincer-like clamps having a movable fulcrum by which the lever-age may be altered. There are two jaws, *A* and *B*, exactly alike, and each having rounded notches in which there may engage a link of rectangular outline and round cross section, *C*. The jaws are corrugated or toothed so as to prevent slipping; and the handles are pressed together (which causes the jaws also to be pressed together) by a

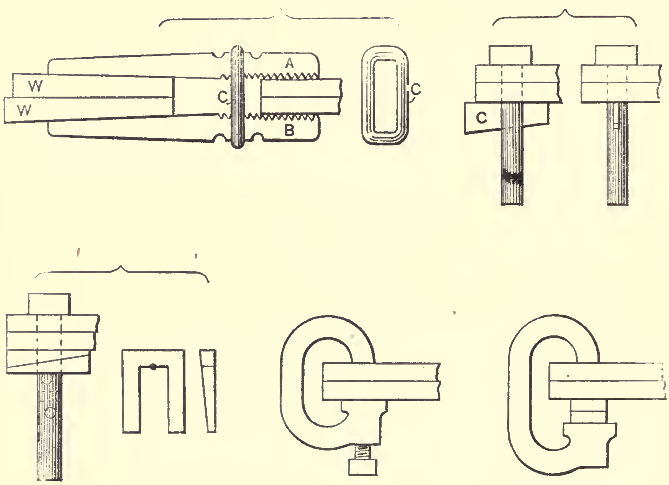


FIG. 78 TO 82.—CLAMPING FLANGES, ETC.

pair of wooden wedges *WW*. For these, a screw may be substituted. These will clamp flanges that have no holes at all in them, and does not take up much room crosswise.

Where the bolt-holes are already in the flanges, the slight device shown in Figure 79 will answer admirably, consisting of a bolt with a large head and slotted stem, through which there is thrust a thin wide cutter *C*. This may be used with or without washers, according to the thickness of the flanges.

Figure 80 shows a modification of this. Instead of there being a slot through the shank of the bolt, there is only a series of round holes, through any desired one of which there may be thrust a round pin; and wedges driven between this pin and the lower flange will tighten up the hole.

Figure 81 shows the ordinary screw clamp which may be used with or without plugs between it and the flanges; and Figure 82 is the same thing used without any screw, wooden wedges taking the place of the latter.

Starting-Drill. Before you start to drill a hole in solid metal, you will find that an angular starting-tool about like this sketch will come in handy.

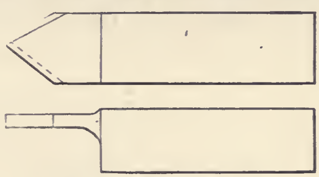


FIG. 83.—STARTING DRILL.

Clamp it in the tool-post and true up the end of the work about the size of the drill; then when you start your drill proper it will be more apt to run true.

Centering-Drill. At the Atlantic Works, Philadelphia, there was produced some time ago a centering-drill shown in figure 84 and consisting of a round piece of steel ground to a point and slit up axially; then placed in the lathe and ground with the apparatus used for grinding the lathe-centers in position.

The spring of the points due to the slit and to the pressure of grinding, causes the cutting edges to twist, taking the shape shown in the cross section; and when turned in the direction in which it was ground it countersinks very smoothly. When fed

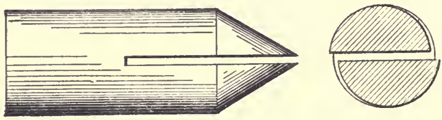


FIG. 84.—CENTERING DRILL. (ATLANTIC WORKS.)

too hard the points close together and the drill ceases to cut; but this can easily be avoided. Its advantages are that it does not chatter, and may be sharpened very readily without changing its shape.

Twist Drills in Sheet Brass sometimes have a habit of leaving a feather edge at the back of the hole. Mr. Wm. Wilkinson, of Philadelphia, states that they will pass through more easily and leave less feather

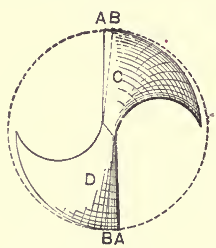


FIG. 85.—TWIST DRILL FOR SHEET BRASS. (WILKINSON.)

edge if the front of the flute is ground back as from *A* to the dotted line *B* in Figure 85, also if the end faces *CD* are given more angle than for wrought or other iron.

Drills for Working Hardened Steel. Once in a while you want to drill a piece of hardened steel or of chilled iron (in the regular line of business; not necessarily with burglarious intent) and then you often find that you have run into a stumbling-block. If the material is not excessively hard, try hardening in mercury (I have pierced files with a drill thus hardened); or you may try a "self-hardening" brand, some of which cannot be cut, filed or punched cold, but is easily shaped cold on a grindstone or emery-wheel without destroying its temper, and by heating it, may be cut or forged to any shape. While hot or warm you must be careful not to dip it in water or other liquid. In forging it, it must be heated slowly and thoroughly to a bright red, and kept evenly hot. In drawing to shape it should have frequent heats. You must take care not to hammer it too cold nor to allow it to get down to a black heat while forging. After shaping, it must cool slowly in the air until perfectly cold, and on no account be dipped in water.

As Regards the Best Form of Drill for this Work there are those who consider that the ordinary twist drill is not a desirable implement with which to do it. One drill which has been highly spoken of for this purpose is endorsed by its originator, a Mr. Sharp, of Omaha, and is made by grinding the cutting edge of a twist drill as near as possible like a flat drill. This machinist thinks that for drilling tool steel, however, there is nothing like a plain flat drill.

Drilling in Glass. The Yale & Towne Manufacturing Co. has occasion to drill 7-16 inch holes in glass ⅛-inch thick. This is done by using No. 5 H emery, with water instead of oil of turpentine as a lubricant. The workman can do 30 to 40 holes per hour; the drill running 2000 turns per minute and the tool being a tube, of which about an inch is used up for every 40 holes. The emery must be kept well washed and clean, with the dust resulting from the abrasion of the glass removed therefrom.

Drilling Long Holes. Many who have essayed to drill long holes with the hog-nosed drill have wished that they had never been born. The principal fun comes in when the drill has been withdrawn and the cuttings washed out, when by reason of the contraction of the metal in the shaft the drill will not enter to the bottom again. Tying waste around the shaft and keeping everything flooded with water helps things along by keeping cool, but has its material and moral disadvantages. A better way yet is to weld a twist-drill of ordinary length on a steel rod of less diameter (say a ½-inch rod for a 17-32-inch drill) using no more oil than is absolutely necessary on the drill itself to keep it from cutting the sides. This dry drilling enables the removal of the chips better then where it is attempted to flood them out with oil.

For Splicing Drills—as where a hole has to be bored that requires drills from five to twenty times as long as the ordinary drill is, although the drill-hole itself does not require to be of excessive depth—take a piece of wrought iron or soft steel rod about double the drill-diameter, make in its end a hole with the drill itself, absolutely parallel with the axis of the rod, and about four drill-diameters deep, cool the drill-shank (assumed to be cylindrical) and heat the drilled rod-end; insert the drill-shank in the hole, absolutely parallel with the axis, and you will have a shrink fit which will be firm enough to hold the drill, yet which can be made to let go when you are through with the job and want the drill again.

Accurate Drilling. In the average shop, when a workman has a hole to drill he makes his cross-marks on a chalked surface with a scriber, then takes a prick-punch and marks a center (which may or may not correspond with the exact intersection of the cross-marks), scribes a circle, takes his punch and makes four prick-marks as nearly as he can on the circle, and then proceeds to drill the hole; drilling away these prick-marks. The chances are about even up that he will not get the hole properly centered; also that if it is wrong that fact does not appear.

In the Bilgram shops, the circle is scribed a trifle larger than the hole is to be, and deep enough not to be obliterated by the chips; no prick-marks are made, and the workman is compelled to drill inside the circle, using the latter itself for the "witness."

This is much better to drill to than the four marks, made with greater or less (usually less) accuracy to represent where a circle is or was; and when the hole is drilled, the circle, being still visible, shows whether or not the hole is in the proper position, and if it is not, how much "out" it is.

Twist-Drill Clearance. If the clearance of a twist-drill is not perfect, the drill will not cut; the application of power to force it to cut will either crush or split it. The proper angle for the cutting-edge is 59°.

Drill-Speed. The Cleveland Twist Drill Co. got tired of having people use its drills at the wrong speed and then complaining that they did not give satisfaction; so it compiled a table showing how fast drills should be used. For steel the speed is naturally slower, and for brass faster, than for iron; and when using the drills in steel, wrought iron or malleable iron it will be necessary to use plenty of oil, or a solution of oil, potash and water. The speeds run for iron, from 1750 for 1-16 inch, through 220 for ½ inch, 90 for inch, 55 for 1½ inch, 45 for 2 inch, and 30 for 3 inch. For brass, 2000 for 1 1-16 inch, 375 for ½ inch, 145 for inch, 100 for 1½ inch, 55 for 2 inch, 35 for 3 inch; and for steel, 1150 for 1 1-16 inch, 145 for ½ inch, 60 for inch, 45 for 1½ inch, 30 for 2 inch, and 20 for 3 inch. For other sizes the speeds come in the same proportion—not a regular proportion, but one having a sliding ratio:—thus for iron, 1 inch has 90, ½ inch 220, and 2 inch 45.

Oiling Long Drills. Sometimes it is necessary to make a very long drill-hole of comparatively small diameter; and in doing this work goes bravely on for the first few feet, but after that there is not only the trouble of backing out to get rid of the chips, but the nuisance of having to oil the cutting portion. In the Pratt & Whitney shops the latter trouble is done away with by forming along the drill a flute or channel, straight or spiral, according as the drill is or is not of the twist type; and then by brazing in a strip of brass, closing up this channel externally so that it acts as a duct for oil, while at the same time not catching any chips. Externally it is turned off true with the outside surface of the drill itself, so that it offers no obstruction in working. Oil is forced in, and comes out with the chips.

This is not a cheap tool to make, but it is much cheaper to use it than to have the tool break in the hole.

By the way, *à propos* of long drilling, Bement &

Miles in making a small 35-foot long hole (three-fourths inch in diameter) through a cutter-bar for "Uncle Sam," ran in 17½ feet from each end, the two bores meeting in the middle and being only one-thirty-second of an inch out of axial exactness. The object in this case was merely to lighten the bar.

Drilling Holes in Water-Mains While They are Full is one of the unusual jobs that a machinist sometimes gets for the first time without being exactly settled

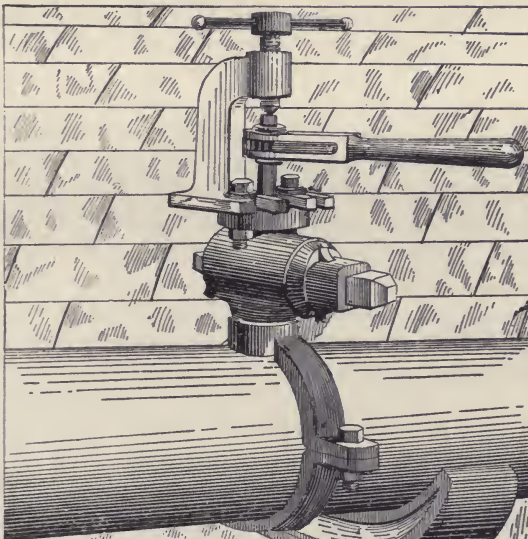


FIG. 86.—DRILLING HOLES IN WATER MAINS.

in his mind as to how it is to be done. Figure 86 shows in a general way one way of accomplishing it, and needs very little explanation. There is a clamp which surrounds the main and which has on one side a boss which is bored and tapped for a male thread on the side of a cock, the plug on the upper side of the shell of which is bored exactly the diameter of the drill which is to be used. The plug being "open," the drill is inserted in the hole in the side of the shell and through the plug, the ratchet and "old man" or other appliances are put in place, and the work of drilling in the side of the pipe itself is commenced. When the drill has gone clear through, as may readily be told by the leakage or by other signs, the ratchet is removed (the plug will come out by the pressure on its end unless this latter is comparatively slight) and the plug turned by a wrench previously applied to the squared end. Then the service-piping may be connected to the body of the cock, which is kept in place by the clamp-ring. Of course this latter has packing between it and the side of the main; sheet lead or copper answering well.

"Morse" and "American" Tapers. There are still shops which have twist-drills and sockets of the old "American" taper, and sometimes it is bothersome to work them in with the "Morse," as the American is 9-16 inch to the foot, and the Morse is $\frac{5}{8}$ inch; the two not interchanging in the same sockets up to $1\frac{1}{2}$ inches diameter, although they do from 1 9-32 inch to 2 inch, inclusive.

Drilling Square Holes. I have recently heard a story which reminds me very much of the condition of affairs at Ridley's shop. A little girl, very much excited, ran into the parlor, which was full of company, and exclaimed "Mamma, just think of it," "Think of what, darling?" "Our cat has a whole lot of twins, and I didn't even know she was married!"

Ridley is very much excited over a new machine for boring square holes with a rotating tool, when, as a matter of fact, he has been doing the same thing for years on about every seventh job that has come into the shop. There isn't a drill-press in his place that is not full of lost motion; and the result is that the spindles wabble at a great rate, and never make a round hole unless luck is dead in his favor.

Now the square-hole machine is only a development of the wabbling drill-press idea. Ridley has been brought up to the idea that square holes cannot be drilled by a rotating tool, and that something in the way of a drill, or of a slotting-tool, is required to make them. But here he has been making them, in a way, ever since his drill-press commenced to get out of truth, and that is over twenty-five years to my knowledge, for it is over that length of time since I first used to peep in and wonder how mechanics could work in the dark.

Cutting Teeth in Large Quadrants. In almost every shop there is an odd job, not suitable in size or some other requirement for the tools at command; and to avoid getting an extra machine some special fixture is made and adapted to a machine in stock. Such a problem confronted the Riehlé Bros. Testing Machine Co. in the requirement to cut teeth in a quadrant of a 48-inch gear. One milling-machine being usually busy on small gears, a plain (not universal) milling-machine was adapted to cut this large diameter quadrant, which was of narrow face and light in casting. As shown in Figure 87 there is a T-iron base-frame or box, in which is pivoted the stud "I." On this stud rotates a worm-wheel having the same number of teeth as the gear to be cut. This gear has a sleeve to which is clamped the gear or quadrant to be cut, fastened by the nut 2. A bracket 3 carries the worm-shaft with the operating crank. One turn of the crank advances the gear to be cut the proper pitch-distance, and a pin at the point 3 of the bracket answers as a stop at which to rest the crank at each turn. The nut 4 on the stud

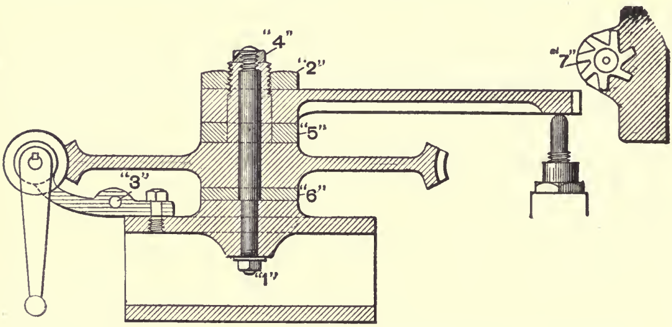
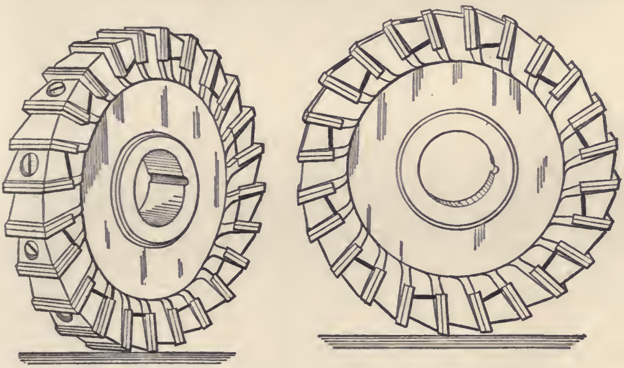


FIG. 87.—CUTTING TEETH IN LARGE QUADRANTS. (RIEHLÈS.)

is alternately tightened and released as the tooth is cut, and then shifted to the next space. 5 and 6 are simple washers to admit of adjustment and antifriction. 7 is the milling-cutter; which in this case is fed down by hand through the tooth, the depth of the latter being regulated by the cross-slide, which is clamped fast when once set. To look at the milling-machine without this fixture, you would not feel encouraged to try to cut a gear of such large diameter.

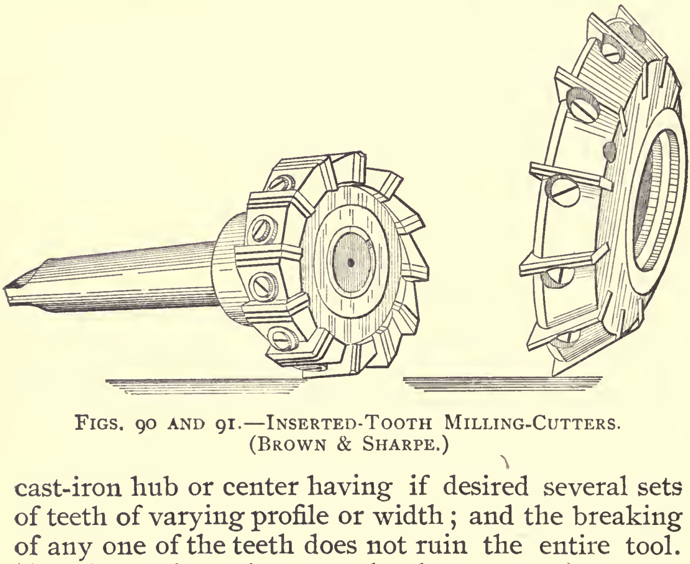
Inserted-Tooth Milling-Cutters. While going through the shops of the Brown & Sharpe Manufacturing Co. I saw a good many things which are not to be met with in the majority of machine-shops in this country. Among them was a form of milling-cutter with insertable teeth, the hub or center in which they were held being of cast-iron arranged to be keyed to an arbor and having on its circumference half as many spaces as there are to be inserted teeth. The fronts and backs of the projections forming or formed by the spaces are milled off smooth and radial, and the teeth, which have full fronts and backs, are slipped



FIGS. 88 AND 89.—INSERTED-TOOTH MILLING-CUTTERS. (BROWN & SHARPE.)

in in pairs so that the front of one fits against the back of one projection, and the back of the one directly behind it comes against the front of the projection next back. This leaves a wedge-shaped space between the back of the front tooth of the pair and the front of the back one. Into this there is slipped a wedge-shaped piece of cast iron, which is bored lengthwise to receive a screw that enters the hub or center radially and which, on being tightened up, draws the wedge towards the center of the hub and crowds the inserted teeth against the projections. The amount of projection of the teeth may be varied by packing-pieces of paper, as for instance when after grinding they have become slightly shorter, or if it be desired to give every other one a trifle extra working depth.

Cutters thus made have the advantages that they are much cheaper in first cost than solid cutters; that the form of the teeth may be altered at will, each



FIGS. 90 AND 91.—INSERTED-TOOTH MILLING-CUTTERS. (BROWN & SHARPE.)

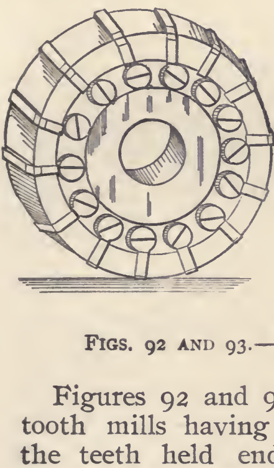
cast-iron hub or center having if desired several sets of teeth of varying profile or width; and the breaking of any one of the teeth does not ruin the entire tool. The sharpening, also, may be done most efficiently with minimum trouble, and calls for less skill and simpler appliances than the grinding of the solid cutters.

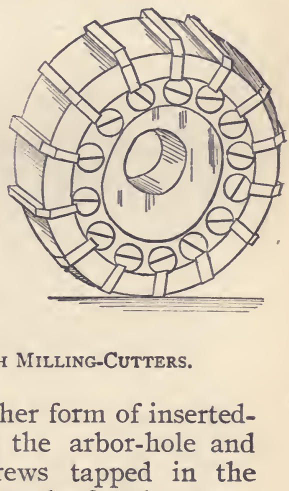
A front view of such cutters is shown in Figure 88, and a side view in Figure 89.

A variation of application of this principle is seen in Figures 90 and 91, in which there is but one tooth for each space between the projections; and the teeth are held in by radial screws passing through conical steel thimbles relieved on one side and passing through the projections so as to lock the teeth in place.

In both styles the hub is keyed to the arbor of the milling-machine in the ordinary fashion.

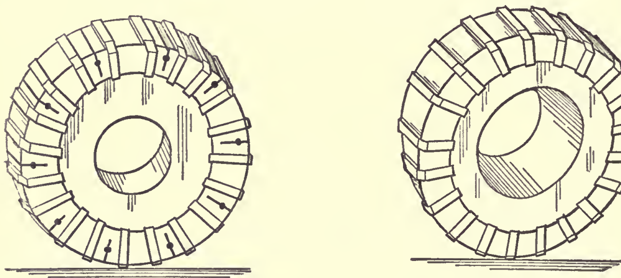
Other cutters, not from the Brown & Sharpe shops, are shown below.





FIGS. 92 AND 93.—INSERTED-TOOTH MILLING-CUTTERS.

Figures 92 and 93 show another form of inserted-tooth mills having keyways in the arbor-hole and the teeth held endwise by screws tapped in the body below the mill. Cuts are made for the dove-tail inserted teeth, and having the heads of the screws bear against shoulders formed in the ends of the mill-teeth, so that their overhanging ends can make radial cuts without having the screw-heads in the way. At one end of the hub these screws are screwed down hard on the hub; at the other the hub is countersunk for the heads so that the screw-head bears on the end of the mill-tooth.



FIGS. 94 AND 95.—INSERTED-TOOTH MILLING-CUTTERS.

Figures 94 and 95 show inserted-tooth cutters having parallel sides put in straight radial cuts in the hub. The teeth slide in the grooves; and about midway of the hub-depth there are taper holes reamed to receive ordinary taper pins as keys.

Adjustable Cutters for Grooving. There are many jobs of plane work for which it often does not pay to make a special milling-cutter, so they are done on the planer, although not so well. It is, however, possible to have some cutters that can do a variety of work, or at least which will work to more than one size. Of course every one is familiar with the "built-up" cutter for *OG* and similar work, and knows that more than one combination may be made of the sections of such cutters, in shops having much milling to do; but I have not seen in as many shops as I should "packed out" cutters like that shown here in the sketch, by which several widths, without a certain range, may be milled by only changing the packing.

The two parts (which need not be alike) have their faces on one side at right angles to the axis, and the other, inclined at an angle of say ten degrees. The thick or wider side of one and the thin or narrow side of the other being brought together on the axis, with a packing-piece of leather or other material between them, the cutter will mill a width equal to

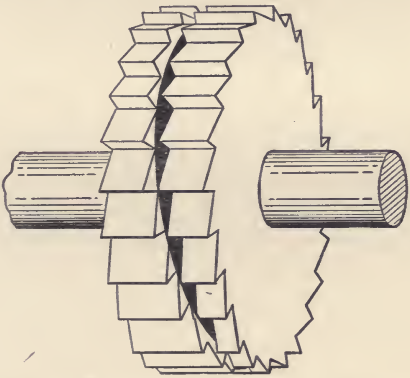


FIG. 96.—ADJUSTABLE CUTTERS FOR GROOVING.

the sum of the widths of the thick and the thin face, plus the thickness of the packing. The narrowest that this combination will mill is equal to the width of the two when put together without packing; and the widest cut that they will make is equal to that, plus very nearly the difference between the wide and the narrow side. That is, if the cutters are alike and have widths of three inches and one inch respectively, of adjacent cutting-faces, they will mill four inches as a minimum and very nearly six as a maximum; the range between varying by an amount as small as the thickness of a single sheet of paper.

Another way of doing this is shown by Brown & Sharpe, and has the advantage that the combined thickness of the two cutters is rather more than the width of the groove which they cut, because their teeth are arranged "staggering." Hard tracing-paper is good as a packing between them to take up wear.

Machine-Steel Milling-Cutters. One of the most expensive items about a shop may be made that of making and sharpening milling-cutters; mounting up to the thousands of dollars in a very short time in a shop of any magnitude; and their cost is greatly increased by not only the high price but the uncertainty of quality of tool steel. The problem in their manufacture and maintenance then is to produce that cutter which shall take off the most pounds of material with the least cost for manufacture of the cutter, for maintaining this last at the requisite degree of sharpness and at the proper outline and dimensions, and for driving it; as dull cutters or those of poor steel may prove uneconomical by reason of the power that they take to drive them, and the time of the machine and tender that they consume. In the Newton shops, I find that they are gradually abandoning the use of tool steel and taking to that of crucible machine steel, case-hardened. Such cutters and reamers are of course much cheaper to make than those of tool steel, while their cut is more greedy.

Milling-Cutters for Heavy Work. To make milling-cutters for doing heavy work having no curved outlines, and take greedy cuts, and at the same time not to go to too great expense in the matter, make a hub of wrought iron a trifle smaller than the external diameter of a regular milling-cutter; bore its periphery full of radial holes one-half inch in diameter, arranged in parallel circles seven-eighths inch apart, the holes in the odd circles alternating or staggering with those in the even ones; and having all the holes of the standard depth (say two inches), properly bottomed. Then make a number of round tool-steel rods one-half inch in diameter and two and one-half inches long, to be inserted in the holes in the hub. Grind off the end of each at a bevel, giving all the same bevel and leaving them all of the same length. These, if given the proper cutting-angle, will, on being inserted in the holes in the hub, constitute cutters, the work of which will lap so as to give a smooth continuous cut. In order to insure that each cutter in each circle gets the same amount of work as all the others in that circle, they may be snipped over with an emery-wheel while the hub rotates. These same cutting-pins may be used in a number of hubs, so that you can have the advantage of a number of large cutters without the expense of forging, profiling and hardening such large masses.

Coarse-Toothed Cutters are often very desirable; they can be sharpened readily without drawing the temper and every cutting-edge can be made to cut faster; there is not so much sliding and rubbing as there are many teeth. In fact, where there is a great number of teeth, there is often a certain burnishing down of the metal by them, which makes it all the harder to cut. Of course the cheapness of a cutter having two to four teeth is a great advantage; and sometimes such a cutter can be made and the job done in less time than it would take to make a complete circular mill. End-cutting tools should have fewer teeth than those which cut on their sides.

Spiral Flutes in Milling Cutters. Very often when a milling-cutter fails to come up to the expectations of the man who made it or designed it, the stock is complained of as being soft or unequal, when it is only the form of teeth (for they may be called so) or the number and disposition of flutes, which causes the trouble.

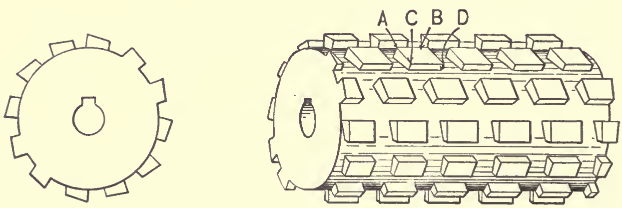


FIG. 97.—SPIRALLY-GROOVED MILLING-CUTTERS.

In the Newton Machine Tool Works, after making many experiments on cylindrical cutters for slabbing, one was found which at first gave great promise of long, hard work. It was made with flutes parallel with the axis, and then each flute was cut up by spiral channels so that the entire tool presented a number of lozenge-shaped teeth arranged about its circumference in parallel spirals; the teeth being probably three-eighths inch lengthwise of the cutter and the spiral channels one-fourth inch wide; while the parallel flutes were about one-fourth inch wide and one-half inch between centers. It would be supposed that such a cutter would mill right along sweetly without hitch or mark; but as a matter of fact it left very perceptible ridges. This was doubtless because the spacing was too regular. Another form was tried (like the former), of case-hardened crucible machine-steel, with parallel flutes as before, but instead of the teeth being divided by regular spiral channels, they were somewhat irregularly divided by cuts which formed nowhere a complete nor a regular spiral. The result was very greedy cutting without being marred by lines as before. See Figure 98.

This is probably somewhat on the same principle

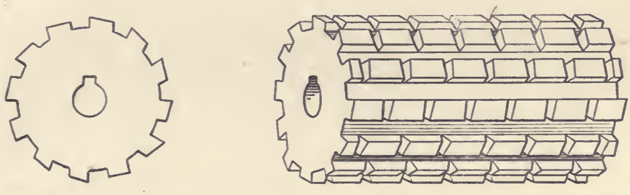


FIG. 98.—MILLING-CUTTERS. (NEWTON MACHINE-TOOL WORKS.)

that hand-cut files are considered (without usually assigning any reason) to do better work than machine-cut; because the latter as usually made (in fact as made by all manufacturers except perhaps the Nicholson Co.) are too regularly spaced; and the matter also calls to mind the fact that taps with an even number of flutes, regularly spaced, do not do so good work as those with an odd number, spaced a very trifle out of symmetry.

Using Oil on Milling-Machines. When you use oil on a milling-machine with a reciprocating table like a planer, there is often some difficulty in getting the oil conveyed away properly to the source of supply in order that it may be used over again. If a rubber tube is used, we all know what will become of it

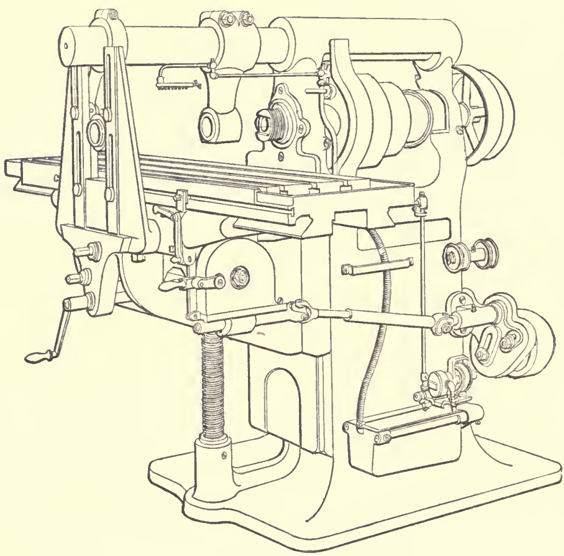


FIG. 99.—FLEXIBLE METAL OIL-TUBE. (ALMOND.)

before the oil has been passing through it long. A rigid tube is not practicable, let it be ever so well jointed. But I found in Brooklyn a flexible metal tube intended for an entirely different purpose, and on suggesting that it be used on a "monitor" lathe to convey the oil to the cutting point of the tool, I found that it had already been used for conveying it away both to and from the work. Figure 99 shows the arrangement by which the oil is dripped in fine streams all the width of the work; then the flexible metal tube carries it away to be pumped up again. For a monitor lathe there would be needed a flexible tube above, which would travel with the turret, and a rigid tube to convey the oil away from the lathe-bed to the reservoir.

Lubricant for Milling-Cutters. All sorts of mixtures are used for milling-cutters; none of them are any too carefully applied. One that is well recommended is made by taking 10 pounds of whale-oil soap, 15 of sal-soda, and 2 gallons of the best lard oil; shaving the soap so that it will dissolve readily, putting the whole in a clean forty-gallon cask and filling with water. When thoroughly dissolved it is ready for use.

Holding Milling-Cutters. Where you have milling-cutters with cylindrical ends, you may hold them while in the machine by means of a chucking-stem consisting of a taper shank fitting the hole in the machine spindle, and having an enlargement bored to receive the cylindrical cutter-shank, slotted through to enable it to be driven out, threaded at the back to receive a ring, and split in three at the end. Screwing up the ring clamps the cylindrical cutter-stem.

To Mill Cuts in the Rim of a Wheel, with the sides of the cut at equal angles with the radius, and to do the work with a cutter of the proper bevel, but having a face at right-angles with its axis, offset and lower the work so that a radial line along the work at the point to be cut will bisect the angle of the cutter; then merely raising the table will feed the work into the cutter at the proper angle, and the cut will be properly divided each side of the radial line.

Axial Reaming. Where it is necessary to ream two holes which have considerable space between them, but must be in absolute axial alignment—as in the case of bearings on the opposite sides of a machine-frame—they employ in the Hugo Bilgram shops a method which I have never seen elsewhere and which produces excellent results. The holes are first reamed nearly to size; then, the frames being set up parallel in proper position, the reaming is finished *in situ;* each hole is made the point of support for the reamer

FIG. 100.—AXIAL REAMING.

while it is reaming the opposite hole, and it is drawn through instead of being forced through; that is, the reamer is worked backwards. Its form is about as shown in Figure 100: *A* being the cutting portion (of the "shell" type), *B* the shank, *D* the squared end, and *C* a tapered bushing, the small end of which is of the diameter of the unfinished and the large end that of the finished hole; the distance between *C* and *A* being slightly in excess of that between the frames. The tool is of course sectional. This insures accurate alignment.

Milling vs. Planing. The general tendency of machine work is to substitute rotary for reciprocating (to-and fro) motion and rotary for stationary tools. We have the circular saw instead of the gate-saw, the rotating emery-wheel instead of the reciprocating file, the rotary planer for many grades of work (especially facing) instead of the planer with reciprocating bed; and now we have milling-machines especially constructed to take the place of the planer with stationary tool, for very heavy cuts, even in flat surfacing or slabbing. One of these machines at the Watts-Campbell shops is reported by Mr. Arnold as taking $2\frac{3}{8}$ inches per minute feed steadily and a cut 18 inches wide in cast iron, the depth being about three-eighths inch.

Milling Spirals. If you have a milling-machine without a swiveling table, and have occasion to mill a spiral, all that is necessary is to set the centers at the required angle on the platen; or if the platen is not wide enough, make a boiler-iron plate about one-fourth inch thick and having one edge cut off at the required angle to the opposite one; clamp it to the platen so that the side that is cut off will be parallel to the desired axial line. Fix a stud having a roller at its end to some part of the frame, so that it will bear on the edge of the plate; take out the cross-slide screw, and by a weight keep the edge of the plate against the roller. Feeding the platen forward will cause the cross-slide and platen to move together crosswise.

Another way of doing it is to have the stud and roller on the platen and the plate fastened to the framing.

Tooth and Flute Spacing. There are cases where regularity is not desirable, and one of these cases is in the spacing of the teeth of milling-cutters and the flutes of taps. It will often be found that the chattering of a tool is caused by too great regularity in the spacing of its cutting-edges; and packing with soap and paper, and similar make-shifts, are resorted to. The best way is not to have the chatter, and this may usually be prevented by a slight irregularity in the spacing.

Keeping Milling-Cutters Sharp. Sufficient attention is not paid to keeping milling-cutters sharp. It seems strange that a man who will take the trouble to strop his razor every time that he shaves will work right along with dull milling-cutters, job after job, without noting whether or not the tools are getting into the work by sharpness or by main strength. If you want to test this and have a job of work to make a great number of pieces all exactly alike, start out with a good sharp cutter and note how many pieces you can handle in one day of so many hours, under average working conditions; then note how many can be made in the second equal number of hours, and so on until the job is done or the cutter gets so dull that you simply cannot go on with any satisfaction. Then you will see how well sharpening will pay as regards the labor-cost for the job, and the time in which a given number can be put out.

Of course with the dull tool there is more power required, and there is more strain on the belts and more wear and tear on the milling-machine; but that is more difficult to estimate. The same remark applies to hack saws and to most other tools used about a shop.

Speed of Milling-Cutters. To lessen the trouble of calculating through all the various steps usually taken in order to get the number of rotations (not revolutions) of a milling-cutter in order to give a desired cutting-speed at the periphery, divide 135 by the diameter of the cutter in inches, to get a cutting speed of about 35 per minute; or divide 150 by the diameter of the cutter in inches for about 40 feet per minute. Thus a cutter one inch in diameter to run about 35 feet per minute, should make 135 turns per minute; a 4-inch cutter to cut about 40 feet per minute, should make only $150 \div 4 = 37\frac{1}{2}$ turns per minute, and so on.

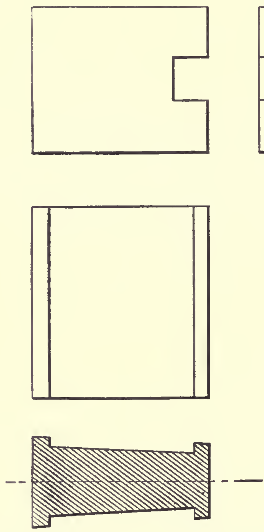
Gage for Cutters of Nut-Milling Machines. In that class of nut-facing milling-machines in which the nuts are strung on a mandrel and two opposite faces milled simultaneously by passing between two rotating cutter-heads with axes nearly at right angles to the mandrel, and a circle of cutters parallel with the axis, it is absolutely necessary that all the cutters on each head shall project exactly the same distance, in order that each cutter shall get its share of the work, and only this; and that the milled work may be free from scores or any other kind of tool-marks.

In order to effect this, the usual method is to have a gage-piece consisting of a metal block having one end truly plane, and in this end a square notch large enough to admit a cutter and as deep as it is desired, to allow each cutter to project (see Figure 101).

All the cutters being first set too far out, they are pushed back by the gage, and then each is held by its set-screw; a work requiring some time and in which occasionally one cutter is skipped, leaving it projecting too far and scoring the work.

In place of this I suggest such a gage as shown in Figure 102, consisting of a wedge-shaped plate, having the sides of any vertical section parallel, and in horizontal section having as much taper as the faces of the cutter-heads are inclined horizontally to give clearance to the cutters.

Two vertical projections on each side, as high as it is desired to let the cutters project, will touch the flat face of the cutter-head; and the plane but not parallel surfaces between will truly gage the projection of all the cutters at once.



FIGS. 101 AND 102.—GAGES FOR MILLING-CUTTERS.

This gage may best be made by the machine at once; the wedge shape being given by running it through vertically.

The Grindstone has not yet been driven out of the machine-shop; but the way that it is treated should have made any self-respecting machine tool leave, if it had means of locomotion. Ordinarily the trough is not large enough; there is no shield so that the water will not splash, or if there is one it is fixed so that the stone can be used from only one side; there are no rests for the tools, or if there are they are fixed so that as the stone gets smaller the rests can not be moved towards the arbor. The bearings are usually too small and have no proper provision for getting oil at them and keeping grit from them. About as often as not they are held on their arbor by wooden wedges which expand with the water used on them, and tend to burst the stone. There should be good sized flanges and the washers should not turn with the nuts. And about as often as not they are used running from the workman. Professional "grinders" who grind paper-cutter knives and such articles, use the stone running towards them.

I see that you have only one grindstone about your shop, for every class of tool, large and small, wood-working and iron-working. Now if you will only reflect a moment you will find that it will be to your advantage to have a harder stone for your planer-tools, and for every tool that is to work iron or steel, than for those which have to cut only wood —and soft wood at that, such as I see that you use principally in your pattern-shop.

I see, too, that your man there is holding his tool so that the stone rotates from him. As the stone is in tolerable balance, he is wrong. So long as the stone is true it should be run towards the tool that is being ground—that is, of course, assuming that the tool is held on the upper side, and with its cutting-edge inclined upwards.

Lathe vs. Grinder. The late Morton Poole, who was the father of the modern high-grade grinding machine, was the first to prove with absolute certainty and beyond the possibility of contradiction, that while no lathe can turn perfectly round, work can be ground perfectly round. The reasons for this fact are that it is practically impossible to keep the live center of a lathe true; that when it is out of true, which is nearly always, the fault is reproduced in the work; that you cannot cut without putting pressure on the tool; and that where the stock is not of uniform dimensions and quality the work of the tool varies with the radius and hardness at the point of cutting. In a grinding-machine the work turns on dead centers, and the work may be turned end for end without affecting its accuracy; and no matter how hard or how soft the stock is, the wheel removes to the same distance from the center. When you consider also that the bearings of grinding-machines are protected against the emery dust, and that it will do as good work on hard as on soft stock, and will handle work that the lathe will not touch, you must admit that the grinder has high claims on you.

Emery Wheels vs. Grindstones. Emery and corundum wheels are gradually and effectually forcing their way into shops and crowding grindstones out; and would do so more rapidly if grinding-machines were given one-half the attention that they deserve and require, and if when there was trouble or apparent trouble, it would be properly investigated. For instance, there is often complaint of "soft sides" on wheels; and these are often only in imagination—the difficulty being caused by gouging when grinding, because the wheel is too soft for the class of tools that are being ground on it, or because the workmen have been grossly careless. Sometimes, also, a wheel will sound and feel, when in use, as though it had a low side, but this will be due only to a small hole or large pore, such as is very likely to be found in a wheel having that amount of porosity which is found to give it the best qualities for grinding.

It will usually be found that one can take from a tool, without heating it enough to draw the temper or even to make it too hot for one's hand, an amount of metal in a given time, which would be impossible with a grindstone, without drawing the temper.

Bursting Emery-Wheels. Quite a commotion in one of your shops as I came along. Emery-wheel burst and took a piece of the wall with it as it went out to look for a shop where they know something abont such things and how to use them. Your foreman says that that is the second wheel that has burst with the same man, and that he seems to be a sort of a "hoodoo" in that particular. Well, I don't think that there is any luck about it. If that man had gone on running emery-wheels the way that he has for the last six or seven years and had not had a few of them burst, I should have considered it luck, and much better luck than he deserved; but for him to have had two wheels burst in your shop, besides the couple or so that he had fly all over the face of the earth when he was working for Adam—I think that is only retribution, or dead certainty, or whatever is most opposed to luck and most to be expected from certain regular causes. Perhaps you are to blame for it a little, perhaps he is to blame entirely; but I would see to it, if I were you, that no more burst in your shop. The next time that one lets go it might break just the other way and fly through you or some of your employees instead of just through the wall and into the scrap-heap.

That man gets about as tapering a mandrel as he can find; he crowds the wheel on it so tightly that the cone of the mandrel has a tendency to break the wheel apart; and then he runs the wheel as fast as he can get it to turn, and wonders that with the wedging action on the inside and the so-called centrifugal action all through it, particularly at the rim, it flies. If he will take a parallel mandrel that is of the same size as the hole in the wheel, and will put some thick paper between the collars and the sides of the wheel, he can hold it centrally without any such tapering nonsense, and if it doesn't run true it can be made to do so in about five minutes, by a diamond-point.

If the makers of that wheel, and of other emery-wheels, had thought it best to use tapering mandrels with them, the wheels would have had tapering holes through them; they would have been much more easy to make. But the makers thought that by putting a cylindrical hole in each wheel, the user would "see the point" and use a cylindrical mandrel.

Emery-Wheel Holder for Car Wheels. It is sometimes desirable to have a holder for an emery or co-

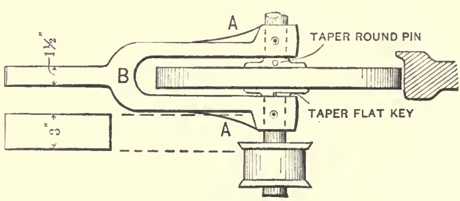


FIG. 103.—EMERY-WHEEL HOLDER FOR CAR WHEELS. (BRIGLEY).

rundum-wheel for use on an ordinary lathe. Mr. John J. Brigley, of Watertown, N. Y., showed some time ago in the *American Machinist* a simple device which he employed for grinding car wheels, the illustration of which is self-explanatory.

Making an Emery-Wheel. Sometimes it will be found difficult to make emery stick to a wooden wheel. Mr. H. A. Seavey, of N. Conway, N. H., has found out that if instead of trying to make the emery stick to the wood we will first glue on felt or heavy woolen cloth and then smear it with hot glue, and roll it in emery heated quite hot, there will be no difficulty about the sticking. Three coats should be given. It is the felt ring or tire that does the trick.

Dust Flues. When one is rigging up a temporary emery-wheel, as on a lathe, and finds it necessary to carry off the dust, about as good a way as any is to have an ordinary tin funnel to which is attached a rubber hose leading into a piece of tin rain-spouting in which a small steam-jet plays axially. This will make enough draft to carry away the dust without trouble.

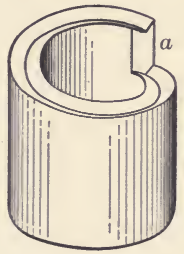


FIG. 104.—FACING-TOOL FOR WORMS. (HARRINGTON'S.)

Grinding Tools Without Changing Their Shape is an advantage when it can be done. In the Harrington works they have a special facing-tool for work on worms, etc., which may be kept always of the same contour and rake by merely grinding it on the face as shown at *a*, Figure 104.

Grinding Standard Gages is a work of aggravation

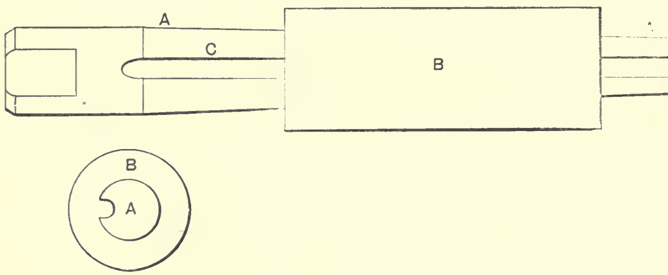


FIG. 105.—GRINDING MANDREL FOR COLLAR-GAGES.

and uncertainty as ordinarily carried out, especially

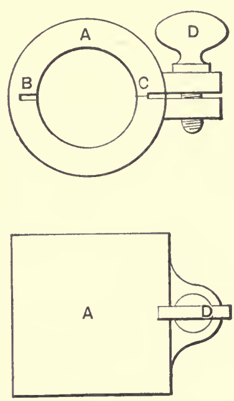


FIG. 106.—GRINDING MANDREL FOR PLUG GAGES.

with the collar, which is apt to have the bore a trifle flaring because the grinding material meets the edge of the hole first. In the Pràtt & Whitney shops they use a mandrel shown in Figure 105; the length *A* being taper and having a flute *C*. The lead is cast on and turned on the mandrel. Driving the taper mandrel through increases the diameter of the lap while keeping it cylindrical.

For the plug gages they use the lap shown in Figure 106; a cast-iron cylindrical body *A* being split partially through at *B* and entirely through at *C*, the screw *D* closing it to take up wear. The split *B* makes it close more readily and admits the grinding material.

For Grinding Iron or Steel Balls a good plan is to have a cup emery-wheel with the inside diameter somewhat smaller than that which is required of the ball; and be sure to strengthen the wheel either by strong Manilla paper bands wider than the hight of the cup, wound around and around with glue between the folds, or by a cast-iron or other cup in which it may be contained, so that then there will be no danger of accidents from bursting of the wheel at high speeds.

Regrinding Rolls. The great and increasing use of both smooth and corrugated chilled cast-iron rolls in flour milling often brings up the question as to whether these rolls, when worn out of truth, can be reground without re-turning the journals. There is no one answer that will fit every case. If the journals remain true the rolls can be reground very readily without extra care, and reground either on centers or (what is better yet) on their own journals. If the journals are out of true, they should be ground—not turned—at the same time as the rolls. The rolls would run truly if ground while running on their own journals, whether these journals were true or not, because any fault in the journals would be corrected in the grinding. But the chance of getting two rolls thus ground, so set in the machine that both sets of corrections would come together promptly, would be too slim for any one to take; hence the journals should be ground, if at all "out." An additional reason for regrinding the journals is the increased life of the bearings in which they run, and the diminished amount of power required to run them.

Corrugated rolls may be thrown out of truth, in recorrugating, even after being ground to absolute truth; this is usually the result of comparatively soft places in the surface causing the tool to sink in too deeply or to pluck out metal, leaving a low spot at the soft place.

It would be well if makers of roller mills would so belt them that their relative velocities would be prime to each other; that is, the same two places should not come together every few rotations, but only at very long intervals. This is often done with gears, so that the same two teeth do not strike each other more than in some hundreds of rotations. The result is greatly increased wear; no one tooth goes much more quickly than the rest, as every tooth comes in contact with every other one.

How to Make Truly Round Balls. Anyone who has ever endeavored to turn balls perfectly round in a lathe may know—and if he doesn't he should know—that there is no lathe built which will turn objects perfectly spherical. In many cases after the lathe has done its work (and this is true of heavy lathes with as perfect fit and adjustment as money can buy) the bolts will be found enough "out" for the error to be perceptible with the finger and thumb. The moral of this is that grinding must be resorted to, to do away with the inequalities of the lathe-work. For such work, the cup emery-wheel (and under emery-wheels I include corundum-wheels as well) will be found convenient and effective.

In Finishing Leaf-Springs by Grinding care should be taken that the grinding-marks run lengthwise instead of crosswise; as when a spring is hardened and tempered it takes very little inducement in the shape of a crosswise scratch or fine groove, such as a grain of emery leaves, to cause the spring to break off short right at the crack.

The Saw as a Machine Tool. There are too few large shops in which the metal-sawing machine is used. There are many classes of work, in the smith-shop, particularly, in which there is a distinct saving in the use of the saw over the ordinary process of nicking and breaking, or of cutting off in the lathe—as, for instance, where it is required to cut a number of pieces to length ready for centering. Where the stock is flat or square, there is even more saving than with round material; and there are cases where there is a piece that needs its corner or end trimmed off or a gap cut out, as in a crank-shaft, in which the sawing-machine will save time and trouble and do better work than can be got by any other means.

Machine Tool. Many a man cuts a piece of work—especially brass-work—into small chips by a regular cutter or lathe-tool, when he could cut it by a circular saw in a milling-machine, or even by a good hack-saw, in less time and with less consumption of power.

The saw can even be used for heavy gaining. For brass-work it is well to have disks which are thicker on the rim than at the center, in order to give the necessary clearance with less weakness than would be given by spreading or by springing the teeth of a disk of equal thickness throughout. Six inches is the largest saw that you will find convenient for ordinary brass-work; and four inches will come in more often as the best size to use for small work.

Cutting Rails to Length. Some of those rails are longer than the others; and the reason of it is that while the gages were set all right, some of them were hotter then the others; and the rails which were the hottest when cut, are the shortest when cold, having contracted more than the others after cutting. In some of the German mills they never have any such trouble; they look at the rail through a dark glass, from which, when they have cooled to a certain temperature, they cannot be seen at all. A dark blue or an orange-yellow glass will make a red-hot rail invisible. It may be considered a fact that any two rails looked at through the same pair of glasses will disappear at the same temperature; if every rail is allowed to cool until it is just invisible through a certain pair of glasses, all will be of the same temperature, and their lengths will be the same.

This is one of the lessons that we may learn from our cousins across the water

For Cutting Small-Diameter Steel a good special hack-saw is about as good as any. Hand hack-saws are of course slow, but they do the work; but there are power hack-saws which will put into the shade any other device for the purpose.

Cutting off Small Pieces. I don't know why it is that people who have cutting-off machines for bar iron of large size should not, when they have a number of small pieces to cut off, place a number of

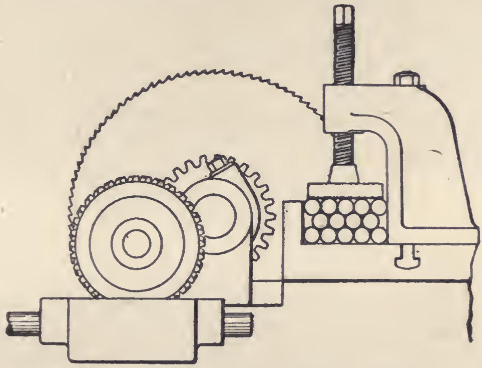


FIG. 107.—CUTTING OFF SMALL PIECES.

them in a clamp at once and cut them all at one operation, as shown in Figure 107, which represents this being done on one of the Newton machines.

Hack-saw Lubricant. I have always been an advocate of black-lead as a useful thing to have around; and one use which is not often found for it is in the lubrication of hack-saws. Two parts of tallow and one of graphite will make a saw cut faster and more sweetly.

Punch-Bushings. A good wrinkle for users of small punches who ruin many by breakage or excessive wear, is the punch-bushing, used in connection with a stock and coupling. The punches themselves are made of Stubs rod, with one end upset with a hammer so as to form a head; this is held in the bush and holder just as a twist-drill is held.

Spiral Punches. The average punch throws too much strain on the press by reason of its cutting all the way around at once. This has been avoided by the Kennedy punch, which, however, is rather expensive to make and troublesome to keep in order. Among about a hundred other "notions," which I have got from time to time from Prof. J. E. Sweet, is

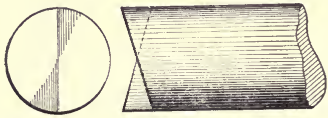


FIG. 108.—SPIRAL PUNCH.

an idea for a punch which should be very useful where there is large work to get out. As shown in Figure 108, the end is divided into semi-circular halves, each of which is ground sloping so as to give a shearing cut, there being always two parts in action at once, and these being always diametrically opposite to each other. The action is a rotary shearing one.

Centering Punch. I do not remember where I got the idea of the centering punch shown in Figure 109; but I think it was in the Delamater Works, from which I always brought away more ideas than I left. *F* is a chunky portion of cheap metal—cast iron, wrought iron, or steel casting, according to the character of work to be done—and it has a screw collar *E* by which to clamp to it centrally and firmly the punch proper, *D*, which has its upper end enlarged and beveled as shown in the illustration. This portion is of the best tool-steel and its working edge *A* is best slightly cupped. Down through its middle there is a hole about half its diameter, and three-fourths its length; and the rest of its length it is bored smaller to receive accurately the shank of a centering-pin *A* with an enlarged head *B* that fits the larger bore. This being slipped into *D* from above, there is next inserted in the large bore a spiral spring *C*; then the

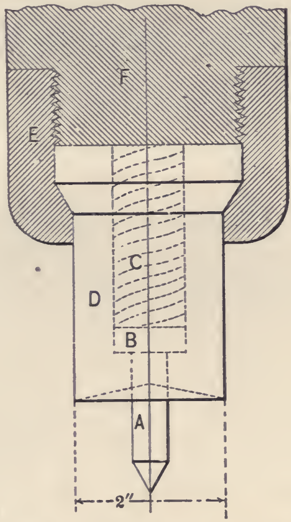
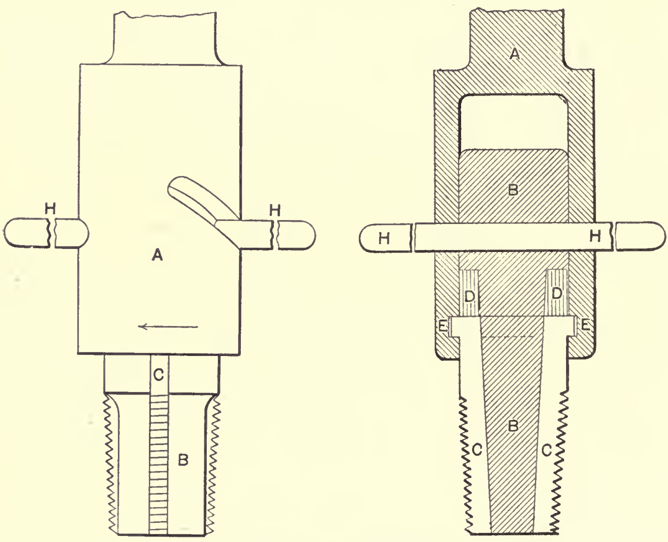


FIG. 109.—CENTERING PUNCH.

collar *E* is slipped over the punch proper, and this is clamped thereby to the head *F*. The spring throws *A* out far enough to enable it to find the cross-mark or prick-mark; then as the punch is brought down *A* recedes and the working edge of *D* cuts out the piece.

Why Taps Break. The reason those taps break in the nicks is that you have made the grooves with straight sides and bottoms. Type-founders know better than that. The nicks that they put in are practically semi-circular in side outline, and their nicks are not intended to do any work. Yours are; yet you have made them of a shape which encourages breakage in the sharp corners.

Collapsing Taps have the advantage that they may be withdrawn without reversing the work, and that they are not (particularly if they have clearance)



FIGS. 110 AND 111.—COLLAPSING TAPS.

worn in that operation. Figures 110 and 111 show one used in vertical machines for steam fittings. *A*, which is driven by the machine spindle, drives *B* through the pin *H*. In *B* are three chasers, *C* fitting the dovetail and taper grooves *D*, and which have lugs fitting an annular groove *E*, worked in *A*, so that if the pin *H* rises the chaser will not rise with it but will close together; if the core *B* descends they will open. When the tap is cutting it is driven as shown by the arrow and the pin *H* is driven by the ends of the grooves; but throwing *H* in the direction of working raises *B* in *A*, closes the chasers away from the thread just cut, and permits easy with-drawing.

Figure 112 is a collapsing tap used by the Hancock Inspirator Co. It has an outer shell *A* carrying three

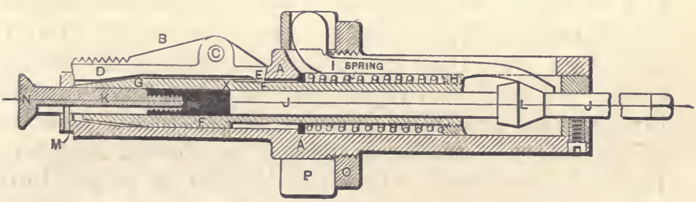


FIG. 112.—COLLAPSING TAP. (HANCOCK INSPIRATOR CO).

chasers *B*, pivoted to *A* at *C*, having a small lug at *E* at one end and being coned at the inner end *D*. The inner shell *F* is reduced along part of its length to receive the lug *E* of the chasers and let them open out full at their cutting end. At the other end of *F* is a washer *H* against which abuts the spiral spring shown, its other end pressing against a shoulder in *A*. The washer *H* is beveled on its end face to correspond with the bevel on a notch in the lever *I*. Within the inner tube *F* is the stem *J*, into the end of which is fixed the piece *K*, on which is fixed the cone *L*. The pieces *K* and *L* are kept from turning by a spline in *K*, into which the pin *M* projects.

In the portion in which the parts are here shown, *F* is pushed forward so that its coned end *G* has opened the chaser to fullest extent; the opening being governed by contact of the lug *E* with the reduced diameter of *F*. In operating in the work, when the foot *N* of *K* meets with the resistance of the end of the hole being tapped, *J* and *L* will be pushed to the right until the cone on *L* raises the end of the lever *I*, and the notch on *I* clears *H*, when the spring will force *F* to the right, and the shoulder on *F* at *X*, will lift the end *E* of the chasers, collapsing the cutting end within *A*, on the pivot *C* as a center of motion.

Frictionless Taps sound like an impossibility, but I have seen some that are verily well entitled to be so called. The thread is first cut and the taper turned in the usual way, then in order better to see what is going on, the blank is heated to change its color. Before being fluted or grooved the blank is put into the lathe with the foot-stock set back the reverse of the way in which the taper was turned; and then with a tool rather more acute than that used for cutting the thread, the bottom of the thread is turned away until there is formed a new angle on all the sides of all the threads up to about ¼ the tap diameter, which is left in its original condition to clear out and leave a finished hole. After fluting and filing away the outer surface between the flutes, such a tap will have clearance all along.

In Fluting or Grooving Taps always back off the threads. There is no way of presenting the cutter which will result in giving clearance, such as can be and should be given by backing off.

Straightening Taps. Making an ugly face over that tap that has got crooked in hardening? Instead of doing that, scour it clean so that you can see what color it has when heated, bring it nearly if not quite up to the temperature at which its temper was drawn, and then you can straighten it without much trouble.

Pipe-Dies made of a malleable-iron frame in which the cutters are held by screws from the back and adjusted by thicknesses of paper will be found convenient for average repair work. The frames bearing the dies can be used in any die-stock of the proper size.

Cutting Pipe-Threads in a Lathe. When you have pipe-threads to cut in any quantity, and have no regular pipe-threading machine, just take off the tailstock of a lathe, put your dies in the chuck, rig up a steady-rest on the carriage, that will grip the pipe enough to keep it from turning, and sail in; using slow speed and plenty of oil.

Three vs. Four Dies for Screw-Threading. There was a time when machinists were somewhat divided in opinion about the relative merits of dies in sets of three and those in sets of four, for pipe-threading. But it seems to me that the question is now about settled in the minds of most, that three dies should do better work, and actually do better work than four, under the same conditions—unless the stock is very thin and very little pressure is put on. On the same principle that it is best to have a large number of flutes in taps and reamers, it is best to have a large number in a screw-threading implement. We will suppose that one die gets dull or broken in a set of four; that throws double work on the one opposite it and there is double the chance of dulling, breaking or bad work; and the same applies all around to meet any case of defective work from one cutter.

Monkey-Wrenches and Pipe-Tongs. There seems to be considerable controversy about the inventor of the monkey-wrench. Some say that his name was Charles, and others that it was Thomas; all agree that he was a benefactor to the race of mechanics—but the English call the thing itself an "adjustable spanner" and cheat him (Charles or Thomas, it is all one at this date) out of the credit which is due him.

But what I want to know is, who invented pipe-tongs? I want to find out where he is boarding, and then I want to go and stamp on him, and give him my opinion of him. Why is it that their jaws are all out of true, even when they are new; that their handles spring; that they only fit about one size of pipe with any degree of decency, and are not satisfactory even then? Why did not the pipe-tong man finish the invention and give us tongs that would grip, or else let them alone?

For my part, there is only one thing which I hate worse than a pair of three-fourths inch pipe-tongs, and that is a pair of inch-and-three-quarter.

In Pipe-Fitting the monkey-wrench may be used as a substitute for the ordinary and usually good-for

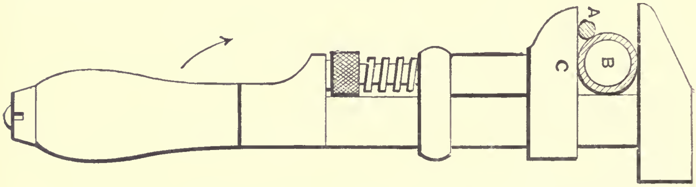


FIG. 113.—THE MONKEY-WRENCH AS A PIPE-WRENCH.

nothing pipe-tongs, in a very simple manner. Bring the jaws of the wrench to the size of the pipe, then put a short piece of an old round file (see *A*, Figure 113) between the piece to be unscrewed, shown at *B*, and the lower jaw *C*, of the wrench. The piece of file will roll between the pipe or nipple and the jaw, and will so greatly increase the grip as to enable good pipe-fitting to be done.

Lead-Pipe Joints. A rather neat way of making lead-pipe joints came to my eye the other day. There was a female die made of conical shape, and this was forced over the end of each pipe and hammered so as to make a cone on each of the two ends that would be joined together. Next they were inserted one after the other in a double-taper collar which was

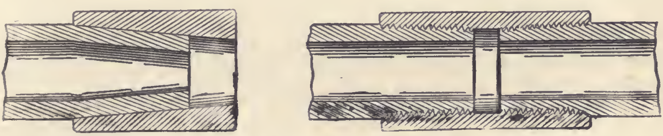


FIG. 114.—MAKING LEAD-PIPE JOINTS.

threaded inside, and were then expanded by a mandrel until they took the form of the threads and were left with cylindrical bore of the original size of the pipe. There is no question about the perfection of the fit between metal and metal in such a job as that.

The only objection to this method is that only short lengths can be added at a time; this being governed by the length of the mandrel.

Globe-Valves in Pipe-Lines. Sufficient pains are not taken in putting up pipe-lines to have the globe-valves with their stems horizontal, to prevent water pockets; and angle-valves are not so much used as they should be.

Bending Copper Pipes as ordinarily effected, by plugging up one end, filling that with melted rosin, and then after bending melting out the rosin again, is troublesome and expensive. The substitution of sand for rosin is sometimes practiced as an improvement on the rosin, as regards the time that it takes. There is a much better way, which leaves the pipes much more truly circular in cross-section at the bends. It consists of taking a spiral of wire, preferably of square section, of a diameter very slightly greater than the bore of the pipe to be bent. One end being supplied with a squared piece to permit of the application of an ordinary carpenter's brace, the spring is inserted in the pipe completely, by turning the brace in the direction of the spiral so as to slightly diminish the diameter of the spiral; then the turning being discontinued, the spiral springs to its full diameter. The pipe may then be bent as though it was a lead rod; and then turning the brace in the reverse way the spiral may be withdrawn from the tube. Curves of any degree of complication may thus be made without any flattening at the bends; the only limit of sharpness of curvature being that imposed by the quality of the metal, which, of course, will "flow" only to the extent permitted by its quality. Curves in all three planes may be made.

Electric Drills in Boiler Work. The old-fashioned way of ratcheting holes in fire-box sheets is slow, and in these days of high-priced labor, costly. A good workman can do with the electric drill as much work in eight hours as by hand in ten, and make better holes. Nowadays, he wheels up alongside of the boiler a little truck, bearing an electric motor, which drives a nest of bevel gears, from which projects a shaft having practically universal motion. If it is a locomotive boiler he engages two hooks which are attached to the drilling-truck or motor-truck, to the engine-frames, fits his drill in the socket, turns on the current, and is ready for work. Within considerable range the motor-truck permits of drilling several holes without moving it parallel to the boiler; but it is literally but the work of a moment to unclamp, move it along three or four feet, and begin again. In the Baldwin Works, where most of the work is done electrically and preparations are made to do more, one man drills as many holes in eight hours with the electrical drill as in ten by hand, and makes better holes.

Reaming Holes in Plate Work, such as boilers, bridges, etc., may be very much better done by a screw reamer such as is shown in Figure 115 than by the ordinary half-round device. It is quite well adapted to use with the flexible shaft.

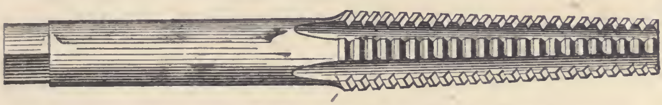


FIG. 115.—SCREW REAMER FOR PLATE-WORK.

Another reamer for boiler work is shown in Figure 116, being a variation on the one just described. It

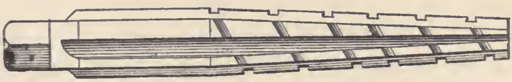


FIG. 116.—SCREW REAMER FOR BOILER WORKS.

has straight flutes, and spiral grooves to break up the chips and help the feed.

Compressed Air for Tapping and Reaming in Boiler-Shops. About as rapid work as one wants to see is that done in the way of reaming and tapping stay-bolt holes in fire-boxes in the Baldwin Works. There is a main running full length of the boiler-shop, on each side, delivering air at 80 pounds pressure. This has numerous points of attachment for hose, with small motors bearing reamers and taps on their outer ends. The workman controls the action of the motor with a cock right at his hand, and reams and taps steel sheets as though he were boring holes in wood. One man can ream 150 holes $\frac{7}{8}$ inch in diameter in steel sheets $\frac{3}{4}$ inch in thickness, per hour, and can tap 40 of the same diameter in the same time in the same sheet. By hand, he would ream only 50 and tap only 20.

Flanging Boiler-Heads, and similar work, requires a very skilled workman, and more judgment than draftsmen usually give in making the drawings therefore. While the excellence of flange-iron is proverbial, too much should not be expected of it, and it is not reasonable to suppose that with a three-inch radius a fire-box or boiler-head will have the metal as little crippled as with a five or a six. Of course when even the best of metal is bent over a short radius, the material on the inside of the curve is wrinkled (it must go somewhere) and that on the outside is stretched and perhaps strained.

A Good Riveted Joint. In these days of high steam-pressures it is necessary to have riveted joints that shall not merely hold the plates together but prevent leakage; and for bridge-structure it is also necessary that the hole be well filled so as to prevent the infiltration of water and consequent rusting; also to do away with lost motion. The late Major E. B. Meatyard (whom to know well was a liberal education) devised shortly before his death the form shown in section in Figure 117. There are three plates, the middle one of which has a hole with parallel sides, as by drilling, and the others having conical outlines, as is usually the case (although not in such a marked

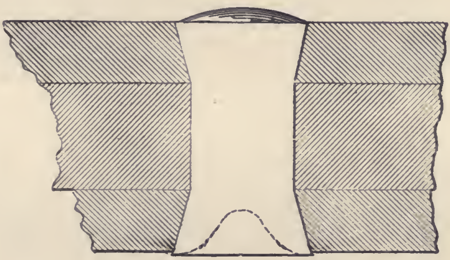


FIG. 117.—RIVETED JOINT. (MEATYARD).

degree as here shown) where punching is resorted to. The rivet is formed with its "first head" conical and slightly convex, and its shank cylindrical; once in place it is expanded by a pin-shaped tool (preferably hydraulically) so that it fills the holes completely, and yet gives a flush joint suitable for ship work.

Boiler-Calking Tools. I show here three styles of boiler-calking tools, marked in the illustration numbers 1, 2 and 3, respectively. The first one has a square end; the second round; the third round also, but with a step on each side, that is, there is a fillet on its end. The first scores and weakens the plate; the second compresses the metal without scoring it, and the third does the same thing only rather better.

The Baldwin Locomotive Works have for many years

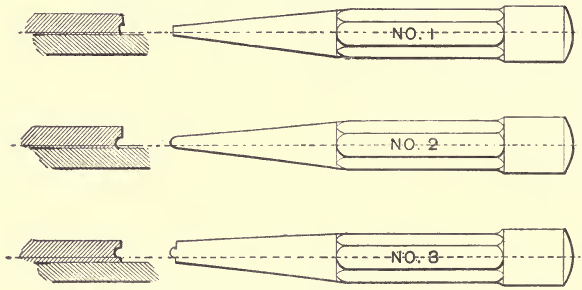


FIG. 118.—BOILER-CALKING TOOLS.

used the second style with the best results as regards the tightness and strength of seams.

Center-Cutting Shears. Shears for cutting off stock operate by leverage; but they are usually made

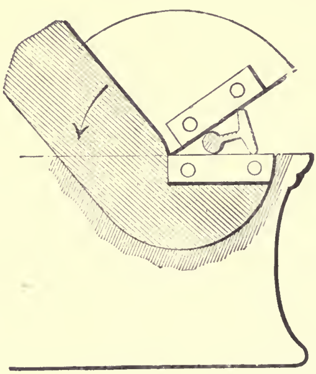


FIG. 119.—CENTER-CUTTING SHEARS.

so that the leverage is decreased by reason of the impossibility of getting the stock near to the center—

where of course the pivot is found. In order to get a chance to cut nearer the center, and thus increase the leverage to the maximum possible (which would be infinite in the case of stock of no diameter), the movable jaw may be given a circular sliding motion about an imaginary center, as shown in Figure 119, where the stock may be brought absolutely to the center, if desired.

True Surface-Plates. Every one who has ever made or used a surface-plate of the usual kind knows that more of the "innate cussedness of inanimate matter" resides in, on or around it than in, on or around any other equal size and weight of material. It is the embodiment of fickle obstinacy, or obstinate fickleness. It is "all things to all men," and various things to one man, according to the temperature, and (some think) according to the time of day and the phase of the moon. It must be coddled like a new-born babe, and humored like a great grandsire of four-score and ever-so-many years. The opening of a door, the removal to a bench on which the sun has been shining—any one of a dozen things will make this supposed "standard" prevaricate like the father of lies; and the worst of it is that the falsehood is inconsistent and ever changing.

Of what use, then, making these things three at a time so as to insure absolute truth, if each one is to be true only when there are two others with which to compare it? Of what avail is the perfection of squareness and flatness, the utmost refinement of finish, if the thing can't be used save under a felt wrapper and in a chamber with fixed and invariable temperature?

There is such a thing as a tool or an appliance being too nearly perfect—being like some men whom we run across sometimes, entirely too good for this world, and yet not quite good enough for the next.

But, granting all this, say you, most intelligent and eminently practical reader—granting that the surface-plate, as we have it, and as Pitt, Planer & Co., have it, and as all the members of the noble army of martyrs to mechanical imperfections have it, is as it is,—most worthy fellow-sufferers, what, in the language of the late unlamented Boss Tweed, are you going to do about it?

As for myself, only to show you what some one else has done about it. If, after hearing of your former fellow-sufferers' revolt from the persecution of a whimsical, inanimate tyrant, you feel like throwing your ancient and dishonorable surface-plate at the traditional cat and making yourself one which can be guaranteed to be like the laws of the Medes and Persians, unchangeable, I shall deem myself to have been of use in the world.

The credit is due to Bement, Miles & Co., of the Industrial Works, Philadelphia.

The trouble with the old style of surface-plate, no matter how carefully ribbed and stiffened on the back, to prevent its being sprung in lifting or in case it was not set squarely on a support, was that its two faces were not alike. One was a flat surface, planed, filed and scraped true; the other a ribbed and cross-ribbed field. The conditions of tension in these two faces were not and could not be the same. Heat could not act on both sides alike, even if they were exposed to the same conditions, which was not at all likely—in fact was hardly possible. The result was as stated, that the plate required special care to preserve it at a uniform temperature in the tool-room, and when taken out for use assumed all sorts of shapes, being alternately convex, flat and concave, according to the time that it had been out of its case; and according, also, to other conditions and circumstances.

Now for the remedy. This, of course, must involve a knowledge of the cause. The cause of trouble being principally non-similarity of the two sides, the remedy was to make both sides exactly alike as regards tension and general condition. Accordingly there was cast a hollow box with all cross-sections rectangular, and having a core also rectangular in every cross-section, and parallel with the external faces of the box; the opposite sides, edges and ends, having equal thickness. This being held in the planer by supports reaching into the core-space, was planed all over, faces, edges and ends, equal cuts being taken off opposite faces so as to keep the opposite strains equal. One side, one edge and one end were then filed and scraped dead flat, and not only dead flat and true, but at right angles to each other, so that the corner where these three true faces met formed a triedral angle (that is, the angle at the corner of a triangular pyramid) of ninety degrees in every reckoning. The appliance as thus finished constituted a surface-plate with maximum stiffness, that would be affected to a minimum amount by such changes of temperature as are impossible to avoid, and which plate could also be used for truing up steel squares, draftsmen's T-squares, and other tools requiring absolute straightness and perpendicularity.

Care of Surface-Plates. Attention should be called to the habit that some careless workmen have of putting surface-plates while in use, where they will get warmed up on one side, or on one not more than the other, so that they will be sprung by the heat of the sun or of the steam pipes. The more accurate a surface-plate is, the more care should be taken to keep it at uniform temperature all over, and as far as possible to have that temperature the same as that of the material which is compared with it. If a surface-plate which has been lying in the sun and attained a temperature of ninety degrees, is laid on a printing-press bed, which by reason of being in a dark part of the shop in a draft has a temperature of only seventy degrees or perhaps sixty degrees, the slab will cool the working-face of the surface-plate and spring it out of true plane, despite its thickness or its ribs; in fact sometimes the thicker it is the more readily it may be sprung.

If the surface-plate has an even temperature of ninety degrees all over, it will remain true unless laid on something hotter or colder; if it has laid in the sun face up, its face will get convex; if it has laid back up, it will get concave on the face. As most surface-plates are longer than they are wide and tend to spring into a cylindrical rather than a spherical surface, the effect of curling by reason of unequal heating may be discovered and to some extent neutralized in work by using them in two directions; once with their length parallel with that of the piece being tested, and again with their length at right angles thereto.

Fine Adjustment for Surface-Gage. If you want a surface-gage that will be simple, stiff, and convenient, and yet have fine adjustment, there was one shown some time ago in the *American Machinist* which should serve your purpose. The whole trick lies in the scriber and in the washers that hold it. The washers are cut out square from sheet steel and soldered together, the hole for the scriber drilled and finished with a rose reamer of the same size as the scriber itself. Then the center-hole is made in the washers and they are turned up round, polished and then unsoldered. When the solder is cleaned off, the washers will bring up solid on their inside

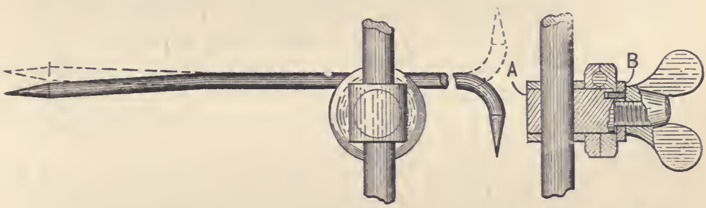


FIG. 120.—ADJUSTABLE SURFACE-GAGE.

faces at the same time that they clamp the scriber. While they clamp tight enough to prevent the scriber from moving endwise through, or the washers being turned on the stud *A*, the scriber can be twisted in its bearing by grasping its hooked end, which gives some leverage. If the scriber is given a very slight bend about one-quarter of the way from the point, turning the hook will cause the point to describe a circle.

To Make a Good Bar Caliper, provide a bar of steel one-half inch in diameter and two feet long, and a brass tube that will just slide over it, of the same length. One-half inch from one end of the bar, drill a one-quarter inch hole at right angles to its length; and in its end drill in to meet this cross-hole, a hole of suitable size to tap off a three-sixteenths inch milled-head set-screw. On one end of the tube insert a wrought-iron collar about three-sixteenth inches thick and three-quarters inch wide, and tap this in its center, for another three-sixteenths inch milled-head set-screw. In the other end of the tube sweat a plug about three-quarter-inch long; in this, parallel with the hole in the collar, drill a one-quarter inch hole, and along the axis of the plug drill a tap for another three-sixteenths inch milled-head set-screw. Provide three milled-head set-screws with cupped ends, one one-quarter inch round hard steel rod eight inches long with a sharp point on one end, and another one-quarter inch hard steel rod eighteen inches long, with one end turned up at right angles for two inches, and both ends ground to a fine point, and the apparatus is ready to put together and use.

This will serve admirably as a bar caliper or as a tram. Additional stiffness may be given if desired—although there is very little work where it will be necessary—by having a second three-quarter inch wide wrought-iron collar sweated on the tube about six inches from the first one and similarly tapped and supplied with a set-screw.

Beam Calipers. It sometimes happens that a pair of beam calipers would come in handy. The arrangement here shown serves both for inside and for outside work. As shown in Figure 121 it has for a beam two one-half-inch round steel rods (these are best of different lengths so that one may be used up to a certain diameter, the other up to a certain large diameter, and both together, fastened by the coupling shown in the sketch, for a diameter greater than the largest that one alone can span). There are made three one-inch steel sleeves, one two inches long, the others each one inch long. The short ones are fitted with one set-screw each, and the long one with two, in line. These screws should have milled-heads, and cupped ends. The legs are of approximately T outline, and are both filed out at the same time from flat steel one-eighth inch thick. They are mortised into the short sleeves, by making on the end of each two round tenons one-eighth inch in diameter with a tight fit into one-eighth inch holes, the same distance apart

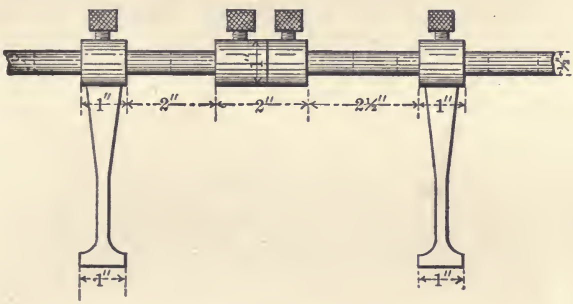


FIG. 121.—BEAM CALIPERS.

in the sleeves. The beams may be graduated in inches and fractions; and if the legs are properly centered with regard to the sleeves, and there is just an inch between the inside and the outside points of each leg, the readings corresponding to the inside or outside ends of the sleeves will correspond to the distances apart of the inside and outside of the legs, respectively.

Bettering Calipers. The question—stiff joints *vs.* spring calipers comes up as often as any in shop talk. An improvement on stiff-joint calipers is one to which my attention has been called by Mr. J. W. Payler, who took a pair of 15-inch stiff-joint calipers, the point of one leg of which he enlarged and then tapped for a small screw to meet the other point, so that when opened to measure any object they can be set by the joint to one-eighth or one-quarter inch larger and adjusted by the screw to touch (just where the touch can be most accurately felt) at the very point of contact with the object. The same thing is used in the famous Bollinckx shops in Brussels :—which, by the way, are largely equipped with American machine-tools.

Compressing Caliper-Joint. Most calipers have a tendency to spring open when used outside, or to close when used inside. A device which they have in the Standard Tool Co's. shops is intended to do away with this trouble. It has legs of unusual width; this being at the rivet end about one-tenth the length, and running on a true taper. This width admits of a large rivet; and in place of the usual rivet and washer (which would soon wear and become loose), they use a hollow rivet or a tube. One leg in each pair has a hole drilled at a point about one-quarter the whole length from the rivet end; then the leg is sawed from the rivet-hole to the one drilled. The tube is cut through one side and spring-tempered; the holes in the legs being just enough smaller to close the tube and to open the slot in the sawed leg. This, as a matter of fact, makes a double spring; the rivet opening, and the hole in the leg closing, as the joint wears in use, so compensating for the usual wear in use. The joint can be made as fine or as loose as desired. The tube being hardened should insure the joint lasting for years without being battered with a hammer as is customary with firm-joint calipers. The width of the stock in the legs is such that the tool makes or approaches a snap gage.

A Thousandth of an Inch is a good deal in a fit, as you may test for yourself by taking a Pratt & Whitney one-half inch plug-and-collar gage, sticking the plug one-eighth inch into the collar and moving the outer end back and forth as though to try the fit. The outer end will move about three-sixteenths of an inch. Many men work much closer than this without thinking that they come within gunshot of it.

The Metric System has been retarded in its adoption by English-speaking people, very largely by the excess of zeal of its advocates, who have been so proud of the elegant regularity of the graduations in every table that they publish every one of the dimensions, although many of them are never used from one year's end to the other, any more than the "mill" and "eagle" are used in our every-day buying and selling. Any one who has ever used the metric system and then had to come back to our abominable divisions and sub-divisions, and to units of weight that have no relation to those of measure, will deprecate any attempt to retard the march of progress by holding on to our antiquated units. We laugh at the Russians and the Peruvians and the Saxons for holding on to the Réaumur thermometer; but what we are doing is ten times worse.

Measuring Screw-Threads. Where there are many screw-threads to be measured it will be found well to have a gage that will measure both the thread-angles and their pitch. As shown in the illustration, Figure 122, there is a sheet-metal gage *G*, having at *a* and *b* teeth to fit the threads. If the edge of the gage meets the tops of the threads, then their depth is right. Where it is desired to test only the pitch, it may be made as shown at *G*, where its edge clears

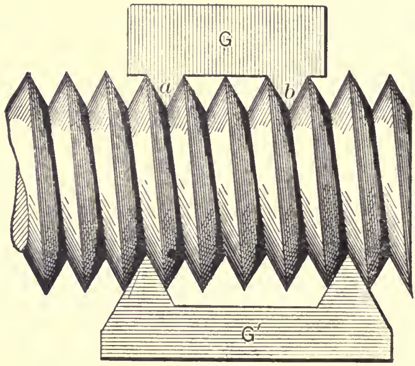


FIG. 122.—SCREW-HEAD GAGES.

the thread-tops, so that it may be tried at several points along the thread-length. Hardened threads need this sort of a test.

Gages for Screw-Threads may be made of saw-blades, and have one side given a pitch to suit that of the screw. The edges should be hardened.

Broaching. Before starting to make mills for a job it may sometimes be worth your while to see if the work can't be done by broaching. It is not usually considered as the best kind of machine work, yet there is a great deal of it done in gun-making; and while the finish is not so good as by milling, there are many jobs which do not call for a mill finish and which, even if they did, could be finished well by other means. Those who do good work of this kind find that it is better to use parallel than diagonal lines of teeth; and say that the work is more readily done on hard than on soft stock.

For Enlarging Square Holes in Cast Iron, the old-fashioned broach is about as good as anything. The stock should be planed square and to size in a shaper, then planed tapering at both ends; then the shaper-vise swiveled so that the teeth will be planed diagonally in order to give a shearing cut. For this work a grooving tool one-eight inch wide answers, its cut-

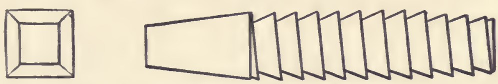


FIG. 123.—BROACH FOR CAST IRON.

ting edge being ground at a slight angle so as to back off the broach-teeth. Thus the broach may be filed and hardened. Of course, it does not keep its size forever, but where there are not too many holes to be made it will save time and files. (Figure 123.)

Milling Out Keys. About as cheap a way of making keys in quantity or even when only a few are

FIG. 124.—MILLING OUT KEYS.

needed, is to mill them out of a slab, by a cutter which is practically a thick saw. This insures that the sides which are at an angle to each other and which do the work, and hence require to be true and well finished, have a perfect surface and a regular taper—the latter being of whatever angle is chosen, and readily determined by the graduated table of the machine. From one slab, either planed off or milled on the two parallel sides, there may be milled a number of keys, " head and tail," the entire stock being used up if the width is rightly chosen. The illustration shows such a key partly milled out of the plate or slab.

Projecting Keys. When a key seems to be too long, as in a crank-pin brass, don't cut it off. Things don't wear longer than they were at first. The brass has worn too narrow or thin. Put some packing back of it, and you will find that the key has the right length again, And, by the way, drive your keys with a copper hammer or a raw-hide mallet; or, if you have neither of these handy, strike it through a block of hard wood. Never touch it with an iron or steel hammer.

"Tapering Straight-Edges." When a green hand starts to learn the hardware business he generally gets sent the first day to find a " left-handed screw-driver " or a " crooked straight-edge." A tapering straight-edge sounds nearly as funny, but why should it not be useful about a work-bench, especially in laying out keys, etc.?

Split Keys. Be careful about trusting too much to split keys. They are usually made of poor stuff, and the short bend which is given them offers every facility for their breaking. They generally manage to break just at a time when such breakage can result in the most damage. Lock-nuts, or nuts which are pinned on, are much better for securing pins, etc.

Key-Tapers and Sizes. Have as few sizes and tapers of keys about your shop as you can get along with; you will save money in their manufacture and much more in their fitting.

Removing Keys. Now that you have one of the ordinary keys running lengthwise of the shaft, and which gives you trouble in getting it out, you may as well have some way of getting it out when you want to take off the wheel. You can get this by having an offset on the outer end of the key; threading this offset parallel with the shaft, and having a nut which you can screw on the threaded end until it jams on the end of the shaft, after which turning on the nut will gradually draw the key.

Pinning Cranks on Shafts. In pinning the crank-hub on that shaft by a pin passing through a diameter of the hub, you are not taking advantage of the full strength that you could get out of the same pin. Suppose that instead of the pin passing through a diameter, as you have it, it were to go through the shaft at a point very near its circumference, forming a chord instead of a diameter. In that case it would present more material to be sheared off than where it runs straight through. Where it goes through the diameter, the amount of material to be sheared off in order to permit the hub being moved on the shaft, is simply twice the sectional area of the keys; but where it forms a chord, that amount may be more than trebled.

Split Cotters. After all a split cotter is a useful thing and prevents much loss and damage. One very nice adaptation of it on a large scale is in the tail-bolts of the M. C. B. couplers on the N. Y. S. & W. Railway. In this case the split cotters are seven inches long and two and one-half inches wide, of flat steel about fifteen inches long, properly turned over. This key is made in the form of a cotter, although it has two cotters which pass through it; and if these latter should drop out the key would be enough of a cotter to hold in place without much risk. (None of them have ever dropped out). In similar way on the same road, the keys which drive and hold the bosses in the connecting-rod ends are kept from dropping out by having a lengthwise groove on the face, on the large end, and into this groove there engages a set-screw which passes through a lug bolted on the top or on the bottom of the stub-end. The set-screw will allow the key to be driven up or slacked back, without the screw itself being moved; but for the key itself to drop out or fly is an impossibility so long as the end of the set-screw engages in the bottom of the groove.

The Set-Screw is an invention of the devil. Either you want a piece to stay where it is without adjustment, or you want to adjust it in position. The set-screw permits of neither to any great degree. It slips if you want it to stay, and holds on like grim death when you want to back it out. If you ever had had to drill one out which had been broken off in its hole you would not be so in love with them. Look how they score up good shafts so that if you want to move the pulleys along you can never use the places where they were for bearings.

A compression hub is the only way to hold a pulley on a shaft.

In Using Set-Screws (the best rule is not to use them at all where they can be dispensed with) care should be taken not to point them. In most cases a flat-bearing surface will answer; but for a good grip their ends should be cupped so as to leave a narrow circular rim about the edge of the end. Anyone who has ever seen a nice length of shafting spoiled by being spotted with set-screw points will acknowledge the wisdom of this recommendation.

For Starting Slot-Headed Screws that have had the sides of the slots so worn down or battered that the ordinary screw-driver will slip out of them, use an "old man" (such as is employed in drilling and tapping), to hold the screw-driver bit down to its place. 'Tis a poor rule that won't work both ways; and the "old man" clamp may be used in backing out a screw just as effectively as in tapering the thread.

The Monkey-Wrench may be put to use as a tube-cutter, among other things, by providing it with two sliding pieces, one for each jaw, and one of which has two rollers and the other a scoring-wheel. The adjustment to fit any size pipe may be made in a moment.

Solid Wrenches. A solid wrench devised long ago at "Cornell," and which will fit a nut perfectly and go on easily, is that shown in outline here. In order to prevent its being used the wrong way, the handle is made of the section shown at *A*; one side being round and smooth and the other having a sharp edge.

It is not likely that anyone, however ignorant or

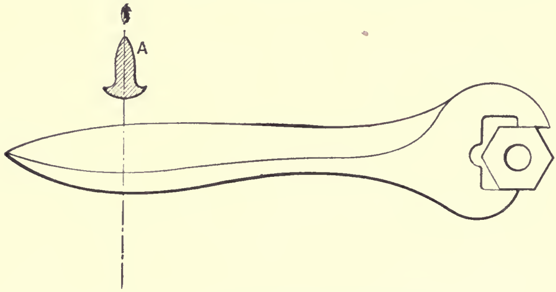


FIG. 125.—"CORNELL" SOLID WRENCH.

careless, will injure either a nut or the wrench very much by turning the latter backwards.

Hammer-Eyes should, instead of being straight-sided, (either with or without taper) be larger at each side than in the center; that is, of slightly hour-glass shape. Then when the wedge is driven in, their bite on the handle will be greater than if their lengthwise section had parallel sides. It would be well also to have a bulge in the handle just below the head, not only to prevent its being driven in too far, but to give greater elasticity. This is Prof. Sweet's idea.

Interchangeable Hammer. Sometimes one wants a copper hammer, sometimes one with a raw-hide head; at other times, again, one with a wooden striking-part. Editor Colvin has invented and put on the market one having facilities for clamping just whatever sort you wish to use; and it is highly to be recommended. There is a malleable iron head-part which may be opened out or screwed together to clamp the blocks of raw-hide or other material.

Another way of doing the same thing, perhaps not so well, would be to make a handle having in each end of the head a socket with a coarse female thread in which there may be screwed a block of wood, copper, raw-hide, hard rubber or other material, as desired, which is provided with the corresponding male thread. Where only a light blow is necessary, the head may be made of hard wood. The male thread for the lead piece may be cast in the iron or wooden female as a mold; a black-lead wash being used.

Improving Steel Squares. To greatly increase the usefulness of a small steel square, fit it with an adjustable blade which is slotted out through nearly its entire length, to receive the shank of a milled head clamping-screw, which is passed through the square at such a point as will bring one edge of the extra blade exactly in the crotch of the angle of the square. With this arrangement the extra or beveling-blade may be placed at any desired angle relatively to the inner edges of the square, so as to permit its use in laying out lines on the ends of cylindrical articles, etc. With a little care, lines may be scribed on the face of the square to permit the bevel-blade being adjusted so as to make an angle of thirty, forty-five or any other number of degrees.

No one yet, so far as I have been able to judge, has had the wit to engrave on the blade or on the stock of a steel T-square a series of graduations such as those on the Gunther's scale, by which with a series of diagonal lines running across two sets of lines at right angles to each other, tenths of the graduations may be laid off with the dividers without trouble, or fine measurements may be made.

With a wooden blade, a small piece of ivory, having just the same graduations as there are usually on the left-hand end of a surveyor's (Gunther's) scale, may be let in.

Tools for One Hand. The ordinary run of machinists have only two hands apiece, and as there are many cases in which there seems to be great necessity for one or two extra, it may be well to call attention to the fact that there are many tools which are now held with one hand and adjusted with the other, which may be rendered much more effective by providing them with stands or handles. Take the micrometer caliper, for instance. It is very easy to mill a slot in the top of a cubical block of hard wood or of cast iron or brass, to receive its bow, so that it may be held with its screw horizontally; and boring out a slight recess at one end of the slot enables the micrometer to be used with the screw vertical; the fit being a neat one.

Measuring Pulley and Shaft Diameters may be very well done by a *very thin* ribbon, in which the divisions, instead of being in inches and fractions of an inch, are 3.1416 inches each, divided into equal parts either in the ordinary binary method or decimally. Such a measure may be readily made by laying down 62.8 inches and dividing it into twenty equal parts, each of which may be divided into sixteenths or tenths as desired. This tape wrapped around a pulley will give its diameter in inches more readily than it may be obtained with a two-foot rule. Mr. H. H. Suplee first called my attention to this, a number of years ago, in the works of London, Berry & Orton.

Limit-Gage. A good idea in the way of a limit-gage to show variations of a given amount above and below standard, is made by the Brown & Sharpe Co. There is a tapered notch which has on one side three marks. At one of these it is standard gage; at the one nearer the edge, say .005 inch more; at the one farthest from the edge, say .005 inch less. It is evident that the less the taper the greater the distance between these marks, so that any multiplication of the fineness of indication may be produced.

Limit-Gage for Worm-Threads. In gaging worm-wheels for hoisting-machinery, Edwin Harrington & Sons use a limit-gage, having its lower plug swiveled to adjust itself to the worm-pitch, and which

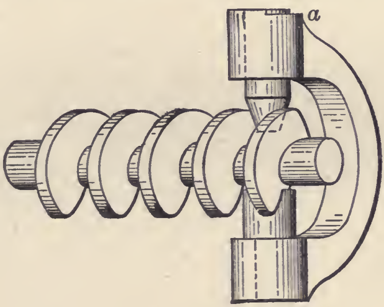


FIG. 126.—LIMIT GAGE FOR WORMS. (HARRINGTONS.)

has a special limit device, as shown at *A* in Figure 126, which is reproduced from "*Machinery*." The cone plug is lightly held to the work by a spring, and the worm is of the right size when the plug is flush with the top of the gage.

Distance Between Babbitted Holes. Where it is desired to have a definite distance between babbitted holes, as in a connecting-rod, the method employed by the builders of the Westinghouse high-speed engine insures absolute accuracy, while at the same time reducing the cost considerably. There is a jig made consisting of a horizontal slab, having in it two vertical pins, which are exactly as far apart as the desired distance between centers of the holes in the connecting-rod; the diameters of the pins being practically those of the crosshead pin and crank-pin. The rod, with the holes previously bored, is placed over these two pins and babbitted in position; the pins serving as mandrels to insure the proper diameter, parallelism, etc., of the holes.

Drilling Jigs. To get two holes in a jig in the same flat surface, at a desired distance from center to center, can be done by the aid of two hardened steel bushings ground to a known outside diameter and lapped out to fit the drills and reamers. If each has a flange they may be fastened to the jig at any desired distance. If there is some one standard diameter of tit on drills in the shop, these bushings may be made of an internal diameter to fit the tits, and this will lessen the cost of producing holes of any diameter.

Distinguishing Jigs and Special Tools. Jigs and special tools such as cradles, gages, etc., may, if large enough, and with some unpolished surfaces, be painted vermilion, as with shellac varnish, which is renewed and dried when the tool has become dirty. This marks them out in distinct contrast from various castings and other pieces of metal around the shop, for which they might be mistaken, and enables them to be very easily found. Especially is this the case where some of them consist of castings which are duplicates, or nearly so, of some of the castings which are component parts of the product being manufactured. This happens sometimes in the case of using a casting as a sample or test-gage, to which to fit other parts.

The experience with this method in the Ferracute Machine Co's. works has proved its great convenience.

True Repair-Work. Enough attention is not paid to the desirability of having repair-work true with the original work on pieces. Thus in injectors, where their check-valves have to be refitted, it is of course important to have the work central with the original lathe-work. This is sometimes neglected. In such cases, as in the railway shop, where there are hundreds of similar pieces to be worked on, it is well to have a jig which screws into the casing and will thus permit the tool working exactly centrally, as often as a valve requires refitting.

Wrinkle in Center-Gages. One difficulty with center-gages is that they do not always have at first,

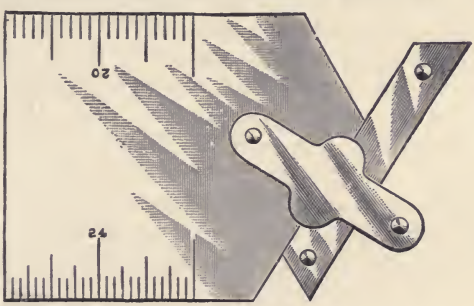


FIG. 127.—ADJUSTABLE CENTER-GAGE.

and even if they do, they usually soon lose, accuracy clear up to the point. A similar trouble existed with saw-sets which spread the teeth; but that was got around by sawing a kerf in the angle and then driving the sides together with a ring. This course cannot so readily be pursued with center-gages, but the same result may be obtained by having the notch made of separate pieces, held together by a ring. These pieces may be ground separately and the contacting edges may be varied by sliding the one of them on the other. I show such a gage in Figure 127; and would say that as far as I know it is the only center-gage that will fit any size of inside threading-tool.

Pinning of Files. Your man is complaining that his file "pins" or fills with copper filings when he is filing down those commutators. There are two ways by which he can prevent it; one to use the file backwards for the finishing touches and the other to chalk the tool well every now and then; the chalk will prevent the filings from sticking to the steel. Another way still is not to file the commutators, but to work them down with sand-paper—not on any account with emery-cloth, because that will fill the places between the sections with a conducting film of oxide of iron. If you will take a block, work in it a semi-circle of the same diameter as the commutator, and line this semi-circle with glass-cloth, you can by turning the commutator at a high-speed and applying the glass-cloth-covered block, bring the commutator to as high a degree of finish as you desire.

Ruining Files. If all those who use files had to pay the bills for them they would be better taken care of. In the first place, no file is improved by being thrown about higgledy-piggledy in contact with other files and with other hard steel objects; yet this is done every day, at the expense of the cutting-edges, every one of which, if not presented properly to hard material, is as tender as a good conscience. Files that have been thrown about have nicks in their cutting-edges, (so-called teeth) and particularly in those on their narrow sides or the edges of the file itself.

Then sufficient care is not taken about using new files only on good and particular work. A new file should never be taken to clean castings or to do any work where a fine result is not desired, and where there are case-hardened or chilled surfaces which will injure its teeth. Yet this is one of the most common difficulties to encounter in shops, particularly those where there is a tool-room and no one man has the certainty that the file which he ruins one day by reason of his being too lazy to go to the tool-room to get a more suitable one, will ever come back again to him. Files are also spoiled by being allowed to clog up with brass-filings and similar materials, which calls for the necessity of putting greater pressure on them in use, and produces irregular wear in spots on the file itself, as well as bad work on the article being filed.

The system of sticking a file up in a bench by its tang is all very well in Chili or some such country where, unless that or some similar precaution is taken, the natives will slip them up their sleeves as fast as the owners' eyes are turned; but it should not be at all necessary in this country, and particularly in a shop where there is a tool-room.

False Economy in File-Buying. I see that you have been buying files of Judkins, and I know why you bought them :—because you saved something on the first cost of every dozen. But if you will take some of those fourteen-inch ones which you have just bought, and weigh a dozen of them alongside of a dozen of the old ones of the same length, face, and cut, you will find that there is about one-fourth to one-third less metal in the new ones. And if you figure it up that you can at best get only one re-cutting out of them, and then will have only some scrap-steel about, you will find out that it pays to buy the heavier files at five per cent. or even ten per cent. higher price. Besides this, if you will let the old hands in the shop have their choice of the two, you will find that they will prefer the old kind, because they take hold better and require less elbow-grease back of them. It is a pretty fair indication of the value of the steel in a tool, to let the piece-work hands have a chance to use it or let it alone. The tool that requires frequent re-sharpening is the one which the piece-work hands don't like; and the file that requires biceps to make it do its work, instead of biting into the work as if it loved it, is the one which the piece-work hands and the "old boys" about the shop will let severely alone as soon as they find it out; and it don't take a man long to find out such a thing as that.

File-Sharpening. *A propos* of files and their work, it is strange that an American invention, the sand-blast, has taken hold so well in England and on the Continent of Europe for file-sharpening, and seems to have been practically neglected on this side, in the same connection. If you will look at a new file you will find that there are on the ends of the teeth, certain small-hooks, and these correspond to the wire-edge on a knife or a razor. Of course they are not desirable; but there is no way of making file-teeth with a chisel, particularly if it is held by a machine, without having these same hooks. The sand-blast cuts files without such wire-edges, and re-cuts old ones better than they can be done by hand; and many English establishments have their new files given a little sand-blasting before they are put in service, the object being to give them better cutting-edges than the makers turn them out with.

Sectional Files. Purchasers of files usually buy them too light, so that they cannot be re-cut more than three times, unless they are large square files, in which case they may be re-cut as many as seven times as a maximum, producing at each successive re-cutting a flatter section than at the preceding one. At each cutting there is about ten to twelve per cent of loss due to grinding out the old teeth. The result is that ordinary files, even of the heaviest kind, cost more per pound of file and more per given weight of metal filed away by them than they should.

When in Germany the last time, I looked into the question of this loss of file-material, and made some calculations based on actual experience, as to the cost, under the present system, of renewal; and the figures that I there got I here give.

An ordinary file 450 m/m (say 18 inches) long by 48 m/m (say 1.2 inches) wide, weighs 3 kilograms, (6.6 pounds,) if it is a heavy one, calculated to stand six or seven re-cuttings. It costs originally 2.40 marks, (say 60 cents) if of bastard cut, and 3 marks if smooth cut. Each time that it is re-cut it loses 12 per cent. of its weight. The price of re-cutting in Germany is 0.40 marks (10 cents) per kilogram for bastard and 0. 60 marks for smooth. On this basis we have

	Weight, Kg.	Price, Marks. Bastard.	Smooth.
1 new file,	3.	2.40	3.
1st re-cutting	2.		
2nd "	2.640		
3rd "	2.324		
4th "	2.046		
5th "	1.801		
6th "	1.585		
7th "	1.405		
	14.801	×.40=5.92;	×.60=8.88
		8.32	11.88
			8.32
Price of two new files and seven re-cuttings of each one -			M20.20

I find that they use in the several shops of the government railways in Prussia, Saxony, Baden, etc., sectional files composed of two blades strained on a wrought-iron handle, supplied with a tang and a wooden handle the same as any ordinary file. Each of these blades is composed of a triple thickness—two films of steel with a thickness of wrought iron between; the steel cut by machine and tempered glass hard. When one side of either blade is worn out it is turned to present the other side. Ordinarily the workman has one bastard and one smooth blade on the holder. The blades are strained between a fixed pin at the tip of the "body," and a sliding pin at the butt, the latter operated by a little wedge. These blades, although as I said, glass hard, were so tough that they could be thrown up in the air ten feet and let drop on the shop floor without their breaking; something that could not be done to the ordinary files in the shop. When both sides of the blade are dull, they are re-sharpened by sand-blast—this being possible only twice. The piece-work hands greatly prefer these sectional files to the ordinary ones, by reason of their superior hardness and convenience; and the workmen, the foremen, and the purchasers, all said that their life was about three times as long as that of ordinary files. Taking the life of one twice as long for these glass-hard blades, as for non-sectional files of good quality; assuming that one of the holders would last through the life of twenty pairs of blades (there is no reason why it should not last longer) and we have, taking the actual costs of sectional and non-sectional files in Germany, the following:

2 blades, bastard cut,	at M 1.60,	-	M 3.20
2 blades, smooth cut,	at 2.10,	-	4.20
4 re-cuttings by sand-blast,	at 0.50,	-	2.
Proportion of the cost of the holder,		-	.15
			M 9.55

as against 20.20 marks for the non-sectional file; an economy of over 50 per cent.

There is also an economy of labor, because these files bite better than the non-sectional; and they are more readily handled; the proprietor of the shop finds also that he can deliver work more quickly, because it takes less time to file it up. As the sectional files are lighter there is an economy in freight and duty. The consumer does not require to carry so large nor so expensive a stock; there is complete independence of the re-cutter; and as the sectional files are non-breakable there are no losses from this cause.

The system is not adaptable with economy in manufacture to files less than twelve inches in length; the sectional files cannot be cut on the edge, and no other than flat files can be made in this way; but with all these drawbacks the sectional file is adopted exclusively by many governmental and private establishments in Germany for all sizes from twelve inches upwards as greatly superior to the non-sectional.

A visit to the factory reveals the fact that the blades are cut while under tension, in a machine which makes from ten to eighty cuts per inch of file-length, and makes them all alike at any desired angle to the length and to the surface of the blade.

File-Tangs have since time immemorial been made with tapering tangs; and these are as well adapted to splitting the handles and to permitting the files to come out, as though they had been specially designed for that purpose. They should be made with parallel sides—that is, of rectangular cross-section; of course avoiding any sudden change of section where they join the body of the file.

The Best Vise-Hight. I should think that your foreman would see, every time that he went over on that side of the shop, that yon have benchmen who are working at a disadvantage in having their vises too high. Watch that man as he works. The top of his vise is higher than his elbow-joint as he stands at the bench; and every time that he makes a forward stroke he has to raise his whole arm, including his shoulder; and even then he doesn't make a straight horizontal stroke. Now if you will lower that vise about two inches, or give the man a platform to stand on, you will enable him to do more work, and better work, with greater comfort, than at present. As the workman's elbow will average between forty and forty-four inches from the floor, you may say that forty-two is the proper average. Fine, light work will permit of, in fact require, a higher vise, than coarse heavy work.

These are among the little things, a few hundreds of which make up the difference between good work and bad work about a shop, or between success in general, and mediocrity.

Bevel Filing. Where there is a great deal of thin

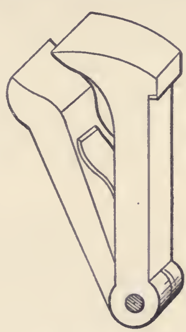


FIG. 128.—BEVEL FILING.

work to be filed at an angle—as the beveled edges of gun-lock plates, etc., the contrivance shown in Figure

128 comes admirably in play. It is placed between the jaws of the vise and firmly holds the object at the desired angle, so that if you file horizontally, the plate will be properly beveled. The spring between the jaws serves to throw them apart as the main vise is opened out.

Finish versus Material. After several years of experiment, more or less costly, the great American tool-using public is beginning to wake up to the idea that you cannot make machine-tools out of filler and stone finish. It has been tried and found wanting, but no longer wanted. Machine-tool users have given hints to builders to put in a little more iron, and a little more iron still, and they have thickened up their patterns, and stiffened up their shafts, lengthened out their journals and bearings, and stretched their slides, and so on all the way around their tools, until they are in one sense like the boy's knife that had had five new handles and seven new blades. But they have the virtue that they stand up under their work and enable bigger and better work and more of it to be done than used to be the case.

Finishing-Clamps. The clamps illustrated in Figure 129, are suggested by Mr. J. S. Converse. The two

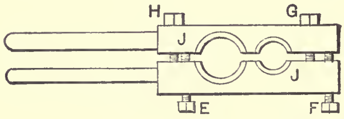


FIG. 129.—IRON POLISHING AND SIZING CLAMP.

screws *E F* thread into the lower half and abut against the other, while babbitt bushes are inserted at *J*. They act as a polishing-clamp if run long enough, without supplying any more emery; and are made in this shape to insure a rounder product than where the clamps are hinged.

Truing off Fly-Wheels. There is often a slight lack of truth in fly-wheels, caused either by their being turned off bodily or being keyed on their shafts improperly, or by local changes taking place, from their being turned down before they have got their "set," in which case they may spring a trifle out of line,

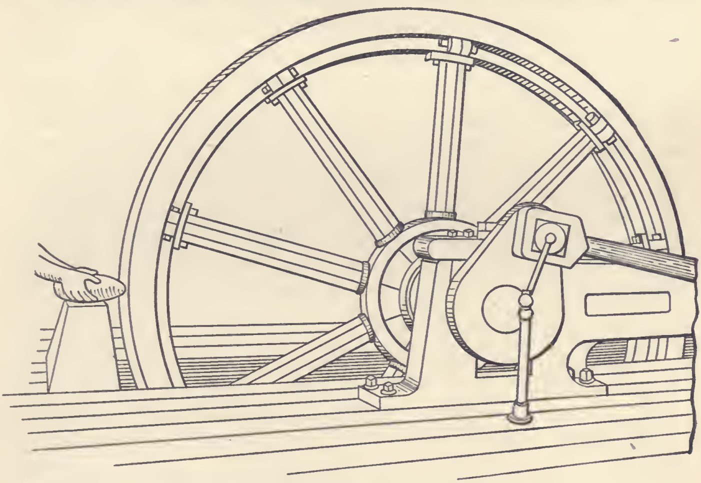


FIG. 130.—TRUING OFF FLY-WHEELS.

after being turned, and then sometimes the finish is not all that could be desired. While "fudging" should be discountenanced except where it is practically absolutely necessary, it is well to be able to know how to "fudge" if there is no other way out of it. One instance of "fudging" is truing-off a fly-wheel after it is in place, and may be accomplished by using a piece of grindstone, with a heavy block as a steady-rest. This, of course, will not remove much metal, but it is practical where there is but a trifle to take off, especially where it is only desired to remove the tool-marks from the rim, in which case it answers admirably.

Colors of Patterns and Core-Prints. In common with many other concerns the Ferracute Machine Co. has adopted black as the standard color for its patterns upon all surfaces representing cored surfaces of the casting. All core-prints are colored red, both where they project from the pattern, and wherever a core would appear in section, at all points thereof; for the core is supposed to be imbedded in the pattern in proper position. This following out of the shapes of the core, so to speak, with red varnish is frequently of great convenience to the moulder as well as the pattern maker, in understanding which way about a core is inserted, how deep it goes, etc.

The Ferracute people color all prints other than core-prints, such as are used for the placing of shafts, studs, staples, and other metal work which is to be "cast in," blue; this being suggestive of the wrought iron which is generally used for such purposes.

All joints of the pattern proper, except those occurring in the territory occupied by the core, are of a yellowish tint, just as the varnish appears on the natural pine wood; they doctor up with yellow varnish places which happen to be of any other color, as, for instance, if made of metal or of dark colored wood, leather, putty, etc. By this system it is always easy o know whether a pattern is complete or whether it is only a part of a whole, which of course is always indicated where there is any yellow surface.

In choosing the solid colors, such as black, blue and red, (these being produced respectively by mixing lampblack, ultramarine and vermilion with shellac varnish) defects due to leather, putty and other materials, incident to cheap construction, can be covered up, and a handsome looking pattern with a uniform surface can be produced. The joints before referred to which are not covered, are usually the easiest to make of a neat appearance by reason of their simple shape, and, furthermore, they are hidden when the pattern is put together. For these reasons this pattern is by many concerns preferred to the one often adopted where the pattern itself is yellow and the core prints black, or *vice versa.*

Pattern-Finishing. Pattern-makers do not often consider the best way of holding work while it is in progress. For instance—in making the "false head" for a steam-cylinder head; it is constructed as shown by the black lines in Figure 131, to fit into the cylinder-head, which is represented by the

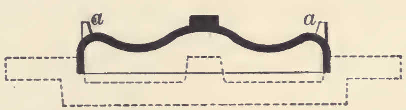


FIG. 113.—LUGS FOR CYLINDER HEAD PATTERNS.

dotted lines. Such false heads are usually designed so that the jaws of a common lathe-chuck will not reach over the round portion far enough to hold them. Now if the pattern-maker would just put on some small lugs (as shown at a, a,) on which the chuck-jaws might catch, there would be no trouble in holding the piece while the edges were faced off where they fit the main head. Then the main head could be chucked and the whole surface turned at one operation. This would save much time in the machine-shop and avoid many straps and bolts.

There are many other pieces—such as pistons, pumps, bonnets, valves, etc., on which it would be desirable to cast lugs in order to save time in handling them in lathe or planer.

Enlarging Patterns for Busts, etc. I saw a good wrinkle being used by an Italian in Paris. There is,

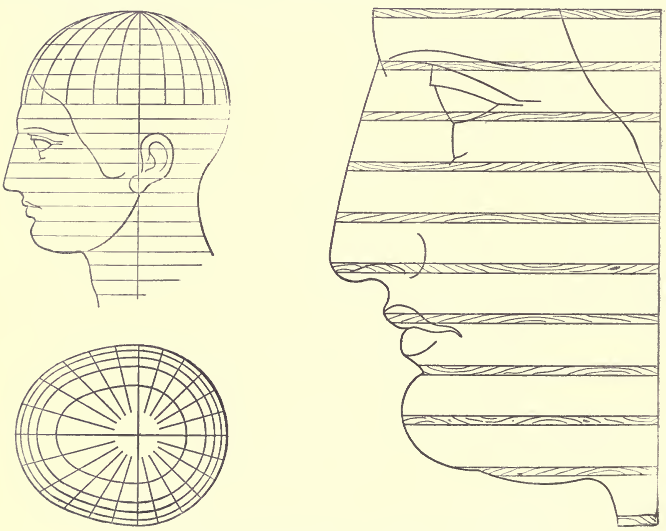


FIG. 132.—ENLARGING PATTERNS FOR BUSTS.

say, a small head of somebody or other—whether it is of St. Peter or of Peter Cooper makes very little difference; it is desired to make a colossal copy of it for use in a bronze-foundry. It is marked off into horizontal planes of equal distances apart; and into radial vertical planes axial with its central line; then the distances are calipered and transferred to a honey-comb-frame, built up of thin boards arranged in planes which are symmetrical with the markings on the original. By cutting into these boards to the required distances you soon have a skeleton which corresponds in outline with the original. The spaces between the thin boards are filled up with plaster or other material, and there you have the enlarged copy made in a very cheap, accurate and practical way.

Pattern-Making. A very good "kink" in pattern-making may be found in the shops of the Ferracute Machine Co. In order to produce cheaper patterns, some of which are rather temporary in their character, and all of which in these days of improvement are subject to alterations, they find that it pays best to put them together in as cheap a way as possible, without any regard to the elegant joiner-work of the old-fashioned pattern-makers, providing they give them strength enough to serve their purpose and get them the right size and shape. In general they pay a good deal more attention to the artistic form, in the way of nicely rounded fillets and corners, and harmonious curves, together with as much absence as possible of external rib-work, than they do to a beautiful job of fitting and joining. To accomplish this they use mill-dressed lumber, planed to accurate thickness as much as possible, and put their work to shape wherever they can with circular and band-saws and "Fox" trimming machines. They avoid ex-pensively-carved wooden fillets, putting in ready-made lead and leather fillets, or oftener, extemporized ones of putty mixed with litharge and shellac, being careful to shellac the surfaces before applying them; sometimes, with large fillets, putting in a few rows of nails by way of anchorage.

To rub the putty down to proper shape, and give sufficient hardness, they use spherical-ended brass formers, which they keep on hand, made to all the different radii required. They find that polished brass works better than any other metal which they have tried, as it does not stick to the somewhat juicy mixture of putty and shellac varnish, as does iron, for instance.

Pattern-Maker's Device. That pattern-maker is spoiling those patterns by jabbing an awl in them to hold them up by when he is shellacking them; and it takes some force to get the awl out again. A better way is to have a tool consisting of a handle having three long fine points arranged in a triangle at its end, and with a clearing-rod running through its center, by which to press off the piece when through with it. This clearing-rod may be a separate piece of stout wire kept in a handy position, or it may be a trifle

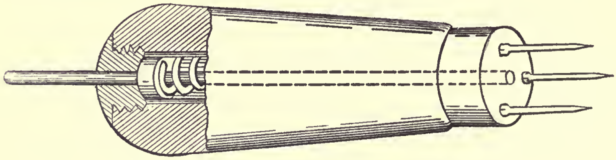


FIG. 133.—PATTERN-MAKER'S DEVICE.

longer than the handle and be contained in the latter, and held away from its pointed end by a spring, so that when it is pressed on, the piece will be clear from the holder; and when it is no longer pressed on, the spring will retire back of the projection of the three holding-points.

Shellac-Can. Pattern-makers may be judged very largely by their shellac-cans, just as restaurants may be given their due rank by the mustard-pot. The can shown in Figure 134 has a jacket around the outside, to hold half an inch of oil or of water as a non-sticking seal for the cover. That is, there is an out-

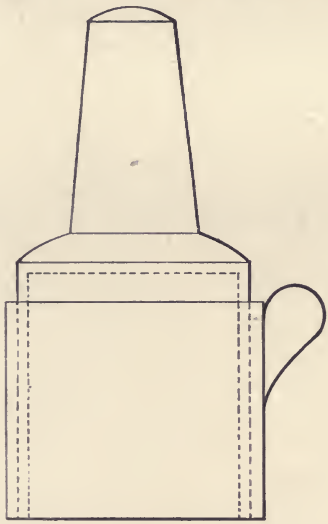


FIG. 134.—SHELLAC-CAN.

side can, or cup, to the bottom of which is soldered an inside one, also open at the top but about half an inch or an inch higher than the outside one. Then the cover fits in between them; it having a steeple-like handle in which the handle of the brush finds room. I got this idea long ago in Syracuse, but forget in what shop.

Feeding Heavy Planks to a Saw. Brains should save muscles. It seems strange why men will exert the maximum amount of muscular effort required to do a particular piece of work, when by the exertion of a very small amount of brain-force they could save hard physical effort. Here I see a man engaged in feeding long and heavy planks to a circular saw, on a long and rough table; there are no anti-friction rollers, and the work of feeding is severe. If that man would only stop a moment, and strew a little coarse sawdust on the table where the planks are to slide over it, he would find that they would serve as anti-friction rollers, or balls, to lessen the resistance of the planks being slid over the table. But if he had charge of that saw-bench for seventeen years he would probably never think of it.

In Making Very Slender Twist Moldings, say from half-inch rods, there is great danger of breaking the stock unless some special precaution is taken; and when the wood is at all brittle, and the pieces to be made are long—say ten feet, as is sometimes needed in screen-work—it is absolutely imperative to do something out of the ordinary run in order to get each piece perfect. This may be done by boring through a wooden block a hole of the exact diameter of the rod and passing the rod through it; then clamping this block in the machine in such a position that the rod will have lengthwise feed as in ordinary cutting, let the cutters work their way through the block form their own passage. They will work the rod regularly into the screw or twist, and the block will remain as a "doctor," holding the rod with absolute smoothness and allowing it to be rotated with freedom while being cut in the spiral.

Of course for such work round stock is absolutely necessary; but as it would be impossible to make it out of such fine stuff, and practically impossible to make it out of any round stuff, unsupported, that will be found no hardship.

Twist-Cutters. There is one class of twist-making machines which work by two sets of rotating cutters, one right and the other left, clamped to opposite sides of a rotating disk, and cutting the material from without towards the center. The knives of this machine have, of course, to be made of a difficult contour to produce the desired outline; but they do not by any means fit the contour of the surface produced, any more than straight molding-knives correspond with the moldings which they produce. It would seem a very pretty piece of geometrical projection to work out the proper outline of the cutters for any given inclination of the cutter-head, (and in this machine the cutter-head has a variable inclination to the axis of the piece) but all this may be done away with by first making a template corresponding exactly to the contour of the molding which forms the twist. This may be the arc of a circle, or it may be an elliptical curve, or it may be any one of a hundred othe curves; but, of course, a template may be made to match it. Next a wooden disk is turned up to fit the molding, lying snug between two threads or turns of the twist. Then taking an arc of this disk-circumference equal to the angle at which the cutters are to be presented to the stock in cutting it, the material is cut down by a saw to the central plane of the disk, and then divided so as to leave a step as it were. The cutting-line will not be radial but will be a chord; the piece removed will be a segment of the disk, and the contour revealed on the piece that is cut away, or on the shoulder that is left, will be the template for the knives; that at one end of the chord for the right-hand knives, and that on the other end for the left-hand knives.

The work may be made even more simple by screwing together two disks and turning them down to fit the twist, being particular to make the parting come at the line where the curves leave each other, so that cutting one simple saw-kerf down from the face of one of the disks will cause the segment to drop off and leave the templates revealed. Pryibils got up this plan.

In Planing Gummy Timber keep at hand a greasy rag, with which to wipe off the face of the plane-body; it will help wonderfully.

A Spur Chuck for Wood-Turning, which is especially good for holding small pieces of soft wood without spoiling them, is shown in Figure 135. The four spurs

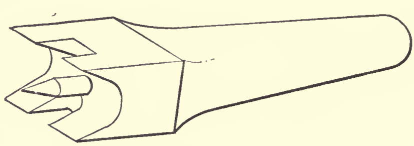


FIG. 135.—SPUR CHUCK FOR WOOD-TURNING.

are parallel on their outer surfaces only, thus compressing the wood between them without spreading the fibers around them.

A Depth-Gage for Boring Holes in Wood is very readily made by boring a hole endwise through a small wooden block and sticking it on the bit; its length being equal to the projection of the bit, less the desired depth of the hole.

Steam-Hammers as Steam-Consumers. The "Shovel Engineer" who has the pleasure (?) of feeding the boiler furnace the black diamonds is no great admirer of steam-hammers except in the abstract. They cause him too much work. Their capacity for steam is practically unlimited. Their appetite is great, and their capacity quite commensurate therewith. There is only one way of getting the best of them—and that is to make them furnish their own steam. This would sound like perpetual motion or conservation of energy, or something like that, but it is the only simple common-sense economy. In nine cases out of ten where steam-hammers are used it is to forge up hot stock; and to get stock hot it is necessary to have great heating-furnaces. All that is necessary to do is to have a passage for the combustion-gases of the heating-furnaces around boilers of the requisite capacity, and the problem is solved—solved in the most satisfactory way, too; because when the hammers are most busy and require most steam there is most heat in the furnaces. In such a hammer-shop as that of the Baldwin Locomotive Works, where the hammers are "made to furnish their own steam" there is always steam to blow off. Yet I have seen shops where good coal was shoveled under the boilers which supplied the hammers, and the heating-furnaces were allowed to waste all their heat.

There are ways and ways of doing things.

Conduits for Air-Blasts. Your men at those forges are complaining that they do not get the blast that they want. It would be a wonder if they did, with the arrangement of conduits that you have to lead the air from the fan to where it is needed. You have the fan rigged up in an out-of-the-way corner where the air-supply to it is not very free; that lessens somewhat the amount that will be drawn in by the blades. You must remember that they are only skimming the air anyhow, and if there is not much to skim they will not be able to skim much from it and pass it where it is needed. Then you have a sort of a wooden pipe which has been cobbled up of almost anything in the way of timber that you had about; and it takes four or five sharp turns horizontally and one or two vertically to skip around and over obstructions; so that by the time that the first outlet is reached there is not much current in the pipe. You should note that while air will press equally in every direction, no matter what the shape of the vessel that contains it, air-currents are different things, and require, in order that they shall be passed on with minimum loss from friction, passages as nearly straight and smooth as can be obtained.

It would have been better for you to have got some large tin pipes, such as are used to carry hot air from furnaces in houses where they know what they are doing. The smooth sides of the tin would not retard the air-currents and make them lag; there could be easy curves and few of them, and then you would have had a good air-current delivered under pressure where you wanted it. If you had such a pipe as yours to carry hot air in your house up-town, you would never know whether there was a fire in the furnace or not, except by going down and looking at it; the registers in your rooms would never tell you anything about it.

Hollow Fires. Where you want an even heat, why don't you learn from your neighbor across the way, and have a hollow fire? You have a bottom tuyere. Wet your coal well, pack it around the inlet and raise the walls as high as you need them. Put in the kindling and fill the middle of the ring with loosely-coked coal as high as the walls are, and then make a dome roof over it, good and thick. Make an opening in front to gain entrance; or, if you want, have it there before-hand by building over a round bar of iron and then withdrawing this.

Hammering Pentagons. When you want to take the conceit out of the average blacksmith, just ask him to hammer out a number of pieces of uniform five-sided section without any dies or other formers. It will probably puzzle him. But should he succeed in producing a regular pentagon, you may bring from out of your sleeve another test which will be very apt to finish him—namely, the equilateral triangular section. Of course, the difficulty is that opposite every side in any piece having an odd number of sides, there is an angle instead of a flat parallel side to rest on the anvil, and in the three-sided piece it is worse than in any other.

Making Cylinder-Jackets. A cored cylinder-jacket is not always a very desirable thing, as one never knows just what the condition of the metal is, next the core. It cannot be revealed by boring, as can flaws in the liner or cylinder-wall proper. Another trouble in casting steam-engine cylinders is that there is nearly always a "pipe end" which, if made extra long, so that it can be cut off leaving nothing but good metal in the cylinder, makes the casting rather more expensive than if no such precaution was taken. A very good thing which I saw in the shops of the Bollinckx establishment in Brussels, does away with both these difficulties. For Corliss engines, of which this concern makes a specialty, there are two castings made; one containing the cylinder-wall proper, with the nozzle, for say the crank-end valves, and a suitable flange, and the other for the jacket and the nozzle for the out-end valves. The first is turned off and the second bored out, and the latter forced hydraulically over the former so that there is an absolutely steam-tight joint between the two; and at the same time no cylinder-flaw is possible.

"False-Back" Couplings. If you have ever had to couple a 2½-inch hose to a 2-inch pipe that was fitted with a regulation 2-inch hose-thread, you have probably had to use a "false-back" female coupling; and this is expensive to make, and unduly heavy. In the early '70's I devised and made in considerable quantity, and the *Journal of the Franklin Institute* illustrated, a coupling in which the two parts were cast together with a water-tight fit. The head was first cast, and a square groove turned in it; this was then coated with black-lead wash, set in the mold, and the shank cast in it. The two parts being chucked by the shank in the lathe, the thread in the head was cut; then a spanner was applied to the head and the lathe run slowly, to cause the shank to turn in the head, which it did, with a water-tight fit.

The idea was so good that a Providence firm patented it, supposedly without knowing anything of my having originated it, for finding that I was filling the country with them, it wrote me to stop it and pay damages.

Interchangeable Pulley-Molding. There are times when the Lane & Bodley foundry might be mistaken for an undertaking-establishment, to judge from a number of coffin-like boxes visible. But they are only core-boxes used by this concern in pulley-molding. In this foundry the pulley-arms are formed by cores and the rims are swept up. The same core-boxes are used for several different lengths of arms;

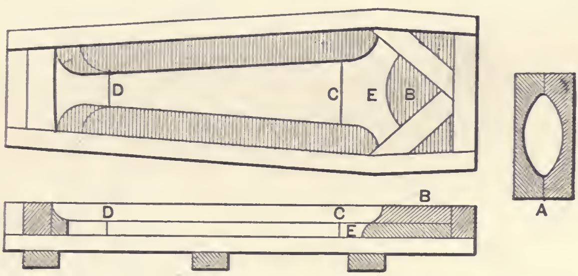


FIG. 136.—PLAN AND SECTION OF ARM CORE-BOXES.

any number of arms desired may be given the pulley. As shown in Figure 136 there is a core-box forming half an arm; two of these put together make the core for a whole arm; and six or eight of these placed around a center, form the arms of a pulley. The hub-piece *E* may be taken off and replaced by one of another diameter of the same standard thickness; each core-box has two pieces for forming the web between *C* and *D*, and two end-pieces. For a fly-wheel with square rim-section, cores are made in the core-

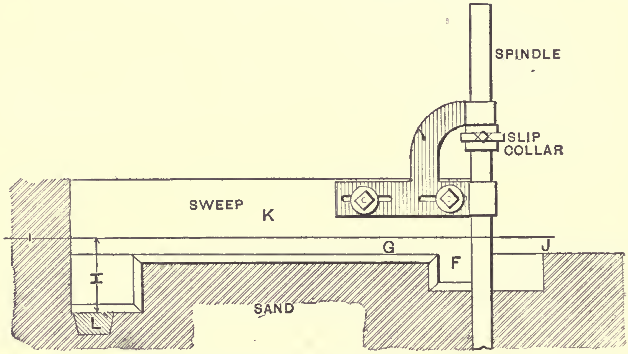


Fig. 137.—Section Showing Sweep for Making the Rims.

room, and while they are drying the molder sweeps

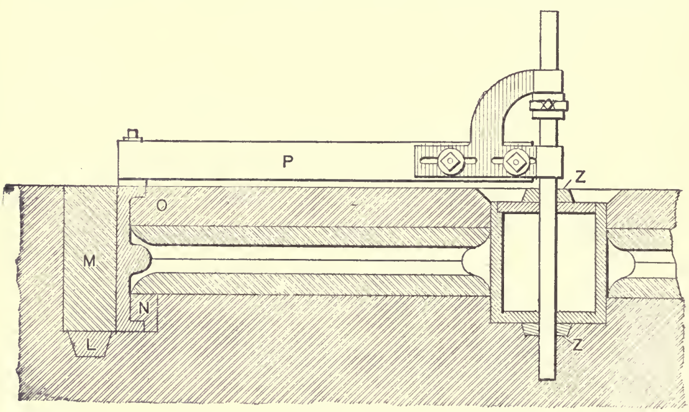


Fig. 138.—Hub Pattern with Arm-Core in Place.

up a level bed for them, using a spindle slipped into an iron socket. Figure 137 shows the sweep; *I* being the center line of the arm, *F* half the depth of the hub, *G* the depth of the core-box arm, and *H* half the rim-depth.

After sweeping up the bed, the sweep is lifted out and the hub-pattern slipped over the spindle as shown in Figure 138; the arm-cores are placed around it at equal angular distances; the rim-pattern, which is only of a segment, is bolted to a second sweep arm and put in place as in the same Figure; then the sand *MNO* is rammed up, the segment moved around, and so on until the entire rim is molded. The check-sand *M* is lifted off, being rammed on the lifter-ring *L*. The rim-segment may then be taken out and the inside of

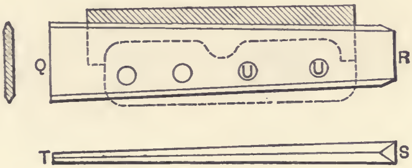


FIG. 139.—WEDGE FOR SPLITTING THE RIMS.

the check and the sand *NO* be smoothed up. After removing the sweep *F*, a small cope is made to cover the hub, and flat cores used to cover the rim.

If the pulley or fly-wheel is ordered in halves (as it should be) rim-lugs are bedded in the sand; a flat core ¾-inch thick is put in the sand, cutting the hub in two; and on this are the cores for the bolt-holes. At the rim there is a wrought-iron wedge as shown in Figure 139, the lower end *Q* being larger than the upper end *R*, so that if it is driven towards *Q* it will free itself and not break away the thin edge of iron at the sides. This wedge is thicker at the upper end *S* than at the lower end *T*. The bolt-cores for the rim-lugs are put through the holes in the wedge *U*, which is well painted with graphite. When the casting is made and cleaned from sand, a few smart blows on the upper end of the wedge splits the pulley, and the break follows the weakest point, at the bottom of the

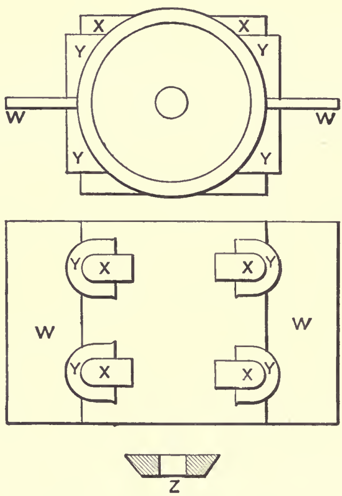


FIG. 140.—HUB PATTERN.

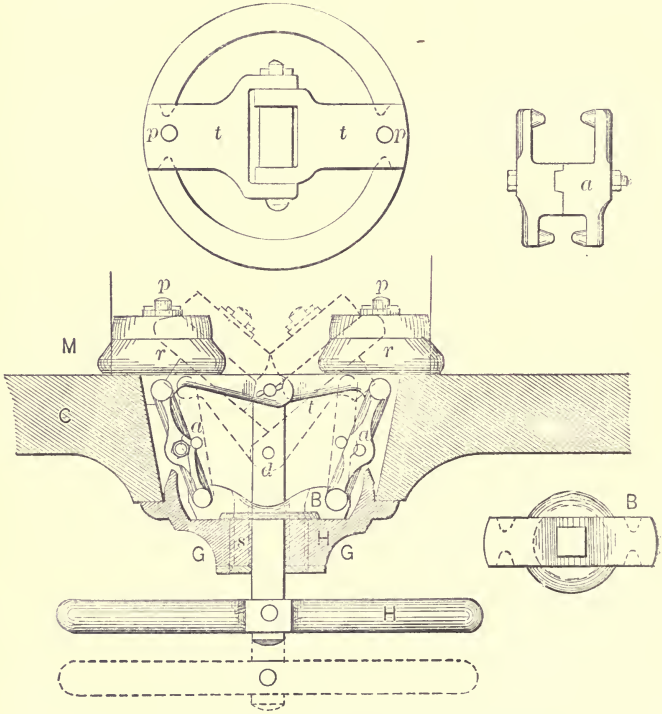
V of the wedge. When the pulley is fitted together, its broken edges make a better joint than if planed.

One set of hub-patterns answers for several pulleys. Their shape is shown in Figure 140. The hubs are hollow with loose tops, which may be removed after the hub is rammed up in the sand, and the pins, which hold the lugs *Y*, with their core-prints *X*, may be drawn in from the outside of the hub. After the hub is taken from the sand the lug *Y* and the splitting core-print *W* may be drawn from this space. The core-prints regulating the bore-diameter are centered by being slipped over the spindle, which also centers the hub as shown at *Z*, Figure 138.

Casting Threads. About Centennial year, I was called upon to make some hose-couplings 10 inches in diameter for suction hose for a pulsometer that was pumping out some bridge-caissons. Such couplings had never been made; and as I did not want them to cost any more than was necessary, as it was a rush job, and I was tolerably certain that I would never get another order, I cast about for a plan to make them cheap, and yet give satisfaction. I decided to cast the threads, both male and female; and this I did, considering the threads only as a means of holding the two sections together, and relying on the washers (which were regular gaskets) to make them water-tight. The thread was four per inch, of triangular section. (If I had it to do over again I should make it three per inch.) After casting, the couplings were chucked and the thread just cleaned out with a tool to get the sand out of them. I had no complaint about the couplings. But as to the hose that went with them:—as Kipling says, "that is another story," which I tell elsewhere.

Casting Straight-Armed Pulleys. There was a time when few foundries would trust themselves to make pulleys with other than curved and sometimes double-curved arms; the object being to counteract the cooling-strains, particularly where the rims were thin. But as pattern-makers and molders got to understand better the laws of shrinkage and of shrinkage-strains, it became possible to make pulleys, the hubs of which would not shrink so much as to draw away from the arms. Straight arms are more sightly and take less metal than the curved ones, and are now the rule.

Forming Beads in Molds. There is a device got out



Figs. 141 and 142.—Forming Beads in Molds.

by a Southerner, by which to form beads in molds, and which should be useful in foundries where water-pipes, gas-pipes, &c., are cast. The mold rests on a chill-plate which is bored to receive a toggle joint, some links and a crank-plate, the sleeve of which latter turns in a guide-plate; and through this sleeve there slides a square shaft. There are rollers turning on pivots which are shrunk in the outer ends of the toggle joint, the center of which latter is connected to the square shaft. Two or three turns of the handle form the bead.

How to Use Graphite Crucibles. People melt faster and faster now than they used to, and then complain that their graphite crucibles do not last so long. It would be a wonder if they did; just as it would be a wonder if the bearings of an engine that ran sixty miles per hour for three hundred and sixty miles a day, would last as many months as when the same engine was running thirty miles per hour and one hundred and eighty miles per day. But to get all the durability or "life" out of a crucible that there is in it, don't submit it when new to the hottest fire that it is to have; use it for the first several times in a new fire that has not reached the fiercest stage. For the highest heats, use old pots.

Choice of Molding-Loam. Choose a loam which is free from iron and from lime, magnesia or other alkaline matter. If you cannot get a good natural molding-loam make one of sand and clay. The alkali in a poor loam will make it too hard and close and cause the metal to boil.

Venting Green-Sand Molds. Where molding-sand is too strongly clayey, green-sand molds may be improved by top-venting and side-venting with a wire, or by the use of ashes in the bottom; and care must be taken not to swab too freely before drawing the pattern.

Renewing Molding-Sand. Founders often forget that molding-sand gets the life burned out of it and requires to be renewed from time to time. Facing-sand of course helps to keep up the strength or life, but not all that is put into the mold remains in the sand; part of it is dissipated and part is carried away on the castings themselves—besides which much of it gets out among the ramming-sand and in the general supply. Of course the constant addition of new material raises the floor-level, but it is always easy to get rid of this excess of material. Experiments made to use the same sand over and over again without renewal have proved failures; scabs are sure to appear as the result, sooner or later.

Coal for Facing can be better ground in a rattle-box or tumbling-barrel than in any grinding-mill proper; and the regular rattle-box which is used to clean castings answers just as well as a more expensive affair. Put the coal in with some heavy scrap iron—preferably in ball form, as there will be fewer pieces knocked off. It will take less power, and you can make more in a given space of time.

Venting Cores. Where a core cannot be vented from the top, there should be laid a good-sized pipe in the mold-bed just below the position of the core, and the latter should be well fastened down—a top chaplet answering in green or dry sand.

Where a core is vented through the side of a mold, whether it be a sand or a loam mold, the core should be well fastened down by a bolt or stirrup where attached to the core-iron, else the kick back may tend to displace the core laterally. Care should be taken in pouring to see that the core-vents burn clear and blue, not yellow; a yellow flame usually indicating that the vent is stopped with metal. The yellow flame is caused by metal reaching the chaff, straw, ashes, coke or other material in the interior of the core.

The colder the metal is run, the more it will need venting. If it is hot and lively it will be able to flatten itself against the mold-wall, even against the pressure of the gases which are trying to get out through the pores of the core; but if it is sluggish, there will be much less difficulty in a current of gas making an impression on the surface of the metal, and the result will be a poor surface.

The use of chaff and straw for venting cores has been adopted for the reason that they make lighter cores, and that in making them, it is somewhat easier to get the proper outline; but the cores are not quite so safe as those vented with ashes. There is more danger of spoiling the casting by the metal breaking through, with chaff or straw rope in the inside, than with ashes, which do not permit the metal to get so far.

Coring Holes in Lugs. Some shops which are not well fitted with boring-apparatus will core holes in lugs, fins or flanges, instead of casting them solid and boring the holes. Very often in such case the hole will have its sides blown by reason of the cores not having been properly vented, or having been wet, or for some other reason the work of coring being defective. A defective place in a lug having a hole by which a heavy piece is to be lifted, may cause a serious or even fatal accident.

Burning Together a Core-Tube. Burning together the two parts of a broken core-tube is done by making a core of an outside diameter equal to the inside diameter of the tube, and about a foot long, sticking one end of it in each of the two ends that are to be burned together, and bringing the parts nearly in contact as they are to be, leaving about an inch between them; then making a two-part outside mold with three gates in it, by which the metal may be poured in at one end on the top, through one hole and run out at the other; then the manner of pouring may be reversed and the metal run the other way. Two or three such pourings and reversals will melt the ends of the tube, and they will be found burned together in a joint which is stronger than the original juncture.

Straightening Core-Tubes. Core-tubes that have got bellied may be straightened by pening; but it will be found that after they have been straightened once or twice, pening no longer has any effect on them; then the only thing to do with them is to break them in two in the center, put the two former ends together for a new center, and burn them together.

Halved Cores. In making round cores in halves the two parts should be put together with a clay slip about as thick as cream.

Every core-box which is made in halves should have some method of insuring that the two parts come together exactly without leaving a step or fin. A shoulder on one half, against which the other half butts, prevents this, but does not keep the parts from sliding lengthwise. Dowels with corresponding holes cost a trifle more, but are more satisfactory. Perhaps a shoulder to withstand the tendency to crosswise sliding, and one pin to keep the parts from sliding lengthwise, will be found best for most cases.

For Sweeping up Loam-Cores on Barrels, there should be a trestle having semicircular bearings in which the core-center may be rotated, as journals; then there should be a straight-edge, longer than the core is to be, and having an edge beveled almost down to an absolute line; this can be used to strike the entire length of the core at once by turning the latter in its bearings. If there is no squared end on the core-center, on which to put a crank-handle, a handle may be put on by clamping.

Removing Tortuous Cores. There are places where a cored passage is very tortuous, where it is difficult to get out the cores; and in such cases there should be left hand-holes about three inches in diameter, the metal around which should be of extra thickness (the re-inforce coming on the inside) so as to prevent the existence of these holes making any likelihood of the wall of the castings giving way at this point; and also to permit the holes to be plugged up by shallow screw-plugs if this be desired.

(Bollinckx, of Brussels, never uses screw-plugs; he forces cylindrical plugs in hydraulically, even in steam cylinder-walls.)

About Core-Sand. Core-sand is the most difficult material for the founder to get good. It requires to be not only porous but adhesive. About the best is that which has been formed by the decay of rock containing felspar, but where (as on a hill-top) it has not had a chance to get water-worn, as will be the case with sand found lower down. There will also be less vegetable matter in sand from the top of a hill than in that from the valley below. Where such good natural core-sand cannot be had, there may be used free sand or pounded blast-furnace cinder, tempered with clay, yeast, pea-flour or horse-dung—but it must be remembered that any vegetable or animal substance added to give porosity is apt to cause boiling of the metal. Fresh sand should be used every time for cores; old stuff will not do.

Core-sand should be, above all things, porous for small cores and for those surrounded by thin walls of metal; it must be just as weak as it can be and be handled and kept in shape. It should be so that it can be readily rapped out of a casting; so that on tapping the casting with a hammer the sand will run out in a stream. No matter what quality of sand is used for cores it will be improved by "mealing" in a rattle-box or other apparatus which will insure perfect mixing. Some core-sand takes much more heat to dry it than others; and if this class is not allowed to be perfectly dry before using, it will blister and scab the face of the casting. Some men get cleaner castings than others just because they use their molds and cores while hot, and for no other reason. There is greater necessity of this in damp weather than in dry, and in damp districts than in dry ones.

Confined cores are best made of free sand because it is more readily knocked out by reason of its loose texture.

Rock-sand serves well for short cores that are held at both ends and which have end-vents; but for long cores the effect of the clay which it contains must be tempered by free sand.

Core-sand should be much coarser than molding-sand, as greater porosity is required of it; and for this reason it will not do to mix old core-sand with the molding-sand. This being the case, the old sand which is shaken out of the castings should be kept away from the molding-sand.

One good core-sand mixture is ten parts of white sand with one of flour, and water enough to make it work easily. This will do for small round and square jobbing work and for where the iron in pouring does not strike the core.

The apprentice should be set to work making cores the first thing. You will find that almost every good molder is an exceptionally good core-maker; care and experience in this line leading to success in molding.

Wooden Core-Boxes. I see that you are using wooden core-boxes for those round cores; and if you will take the trouble of inspecting and calipering those which have been made for a while you will find most of them out of round very perceptibly; the wood having shrunk unequally. Where a core-box for round cores is to be used several times at wide intervals, it should be of cast iron, which has the habit of keeping its shape.

Another thing that I notice in your foundry, is that some of the men do not wet their core-irons with clay-water or clay-cream before putting them into the sand. The sand will not cling to them well without. And in the large cores you are using wrought-iron core-irons, which cost much more than cast-iron ones and are not quite so good, not having so many roughnesses for the sand or the clay-wash to stick to. You will find, too, that you can use ashes for the center of those large cores, serving the purpose of vent-wires.

Baggy Cores. The trouble with those cores is that they are "baggy" from being heated too hot in the core-oven; and they are slack on the core-bar through contraction of the core and expansion of the core-iron taking place at the same time. Those are large cores; and instead of heating them so high to dry them they should have been put in the stove after each couple of courses of straw and loam. Made that way they will take more time, but you will have fewer spoiled cores and ruined castings, and it will pay better in the end.

Core-Oven Doors. The Straight Line Engine Com-

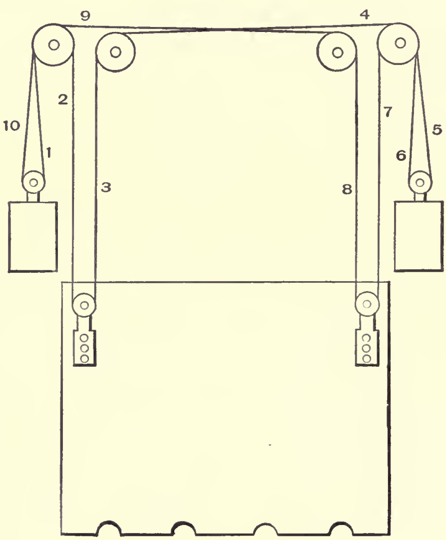


FIG. 143.—CORE-OVEN DOORS. (STRAIGHT LINE ENGINE CO.)

pany has its core-oven doors counter-weighted in a manner which insures both sides going together without guides, as shown in Figure 143; the ropes being strung in as is indicated by the numbers.

Core-Oven Shelves. In the Cresson shops at Germantown Junction, Philadelphia, the core-oven is cylindrical and has in the center a vertical shaft bearing circular shelves for the cores; these shelves being loose on the shaft so that any one of them may be brought around in front of the door without disturbing the others. As they rest on collars fastened by set-screws only, the vertical distances between shelves may be varied to suit the cores being dried. The heat from this oven is taken from the brass-furnaces instead of being wasted.

Core-Oven Cars. There is rather a good thing in core-ovens in the shops of the Straight Line Engine Company, (where indeed one can get a hat-full of wrinkles in short order.) This concern has a large core-oven with four rails for cars, equal distances between centers. There are two cars half the length of the oven. They can be set side and side for large

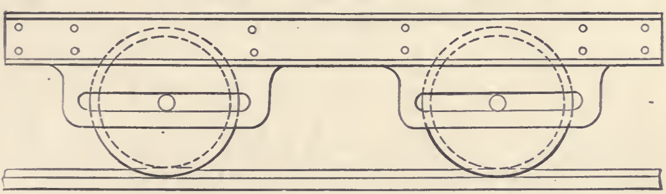


FIG. 144.—CORE OVEN CARS. (STRAIGHT LINE ENGINE CO.)

square or round cores, or end to end on either of three places for round cores. The journals are arranged to run without oil. The slots for the journals are long enough to permit the cars to run twice the depth of the ovens before reaching the end. The wheels have the flanges outside the rails only, which is all right for cranes or for cars of this kind, where they run on straight tracks. The inside flanges, when they hit the rail at all, are considered to do more harm than good.

Portable Brass-Furnace. In the Paris works of Mons. A. Piat, (an engineer and machinist who has done more than any other one person to make popular the use of herring-bone gears) they use a portable brass-furnace which has several good points. The crucibles are mounted firmly on a fire-brick base in a wrought-iron casing lined with fire-clay, and mounted on wheels. In starting up, where blast or strong draft is desired, this portable furnace is set in a chimney way; but once the melt is made the whole affair is brought to the pouring-place, and as the crucible, case and all, is swung on trunnions, pouring is readily done, always with hot metal.

How to Get Good Castings. I don't suppose that any one could give in ten minutes a treatise on the art of iron-founding; but in ten minutes the entire principle of successful castings may be stated. For instance, there your man is making a mold in which he is going to put the runner in a thin part instead of a thick; a big "don't" would be of use to him if he would heed it. Then he is going to run the metal in at the top, although it is a deep casting. The man next but one to him is going to run that flanged pipe at a point in the length of the pipe instead of at the flange; and I see that that long thin branched piece has been run at one end instead of from the center.

It has not taken me two minutes to point out three or four very grave faults in your foundry-practice, from actual observation of bad work; and I believe that by going about and seeing bad work in other foundries it would not take me long to get up rules which would not require ten minutes to pronounce, but which would enable good work to be done if the men would only pay attention to them and use their knowledge-boxes more than their tobacco-boxes.

Cooling-Strains on Ring Castings. To see just how the cooling-strains come on a ring casting, such as is used for piston-packing rings, cut or break a piece out of one and commence to turn it down from the outside. When expensive, and where perhaps there is only one casting to be made, there may be made a pattern like the core that is wanted. This may be molded in the sand with strengthening-wires lengthwise and cast with a composition of two parts of brick-dust and one of plaster of paris, mixed with water. When this is set it should be taken out of its own mold in which it was made, and put into the one in which it is to act as a core; care being taken not to let any cold air get to it.

Casting Solid Iron Balls. The reason why a ball cannot well be cast solid in the center is that it cools first on the outside next the mold, and the metal in the inside pulls away from the core, towards the outside layer. If the ball be chilled, the trouble is more pronounced than if it is a green-sand casting. This matter may be remedied somewhat by "feeding" the ball while in the mold, up to the last point at which it is possible to make it take more metal.

Weights of Castings. In figuring up the weight which a casting will have there must be considered (1) the weight of the pattern, (2) the specific gravity of the pattern, and (3) the specific gravity of the metal from which it is to be poured; but this cannot be done if there are core-prints on the pattern. Where there are no core-prints it will usually be found that a cast-iron casting will weigh 14 times as much as a pine pattern, 13.4 times as much as one of linden (bass), 12.8 as much as alder, 12.8 as much as birch, 10.2 as much as pear, 9.7 times as much as beech, and 9 times as much as oak. With metal patterns cast-iron castings will weigh about the same as zinc, 0.89 as much as tin with 20 to 25 per cent. of lead, 0.84 as much as brass, 0.64 as much as lead; while an iron casting from an iron pattern will weigh about 0.97 times as much.

The Melting-Points of the Metals differ, of course, according to circumstances; but the following will be found to be fair averages and should be kept for reference:

	Deg. Fahr.	Deg. Centigrade.
Cast iron - - -	2507	1375
Gray pig iron - -	2327	1275
Copper - - -	1992	1088.8
Gold - - -	1992	1088.8
White pig iron - -	1967	1075
Silver - - -	1832	1000
Zinc - - -	779	415
Lead - - -	630	337.2
Bismuth - - -	512.6	267
Tin - - -	451.4	233

Most alloys melt at lower temperatures than would be due to the melting-points of the simple metals of which they are compounded. Phosphorus increases the fluidity of most metals; sulphur decreases it;

zinc increases the fluidity of brass, German silver and bronze, and lead does the same thing in bronze and most other tin-alloys.

Chilled Castings. You seem to be laboring under a bad case of imperfect chill, over there in the foundry. If you will try using a little "spiegeleisen" you will find that you will get more chill than you now have; and if what you try does not give enough, you can try until you get what you want. I have seen chills eight inches deep at Gruson's foundry, in Buckau, near Madgeburg, run off as an every-day occurrence. What they can do there you can do here. You may not want to get eight inches of chill, as you may not be casting sections for cast-iron forts as they were, but you can get just as much or as little chill as you want, always bearing in mind that the mere fact of pouring metal in a chilling-mold does not necessarily give a chilled casting. Otherwise you could chill lead, or anything you wanted, as hard as car-wheel treads or lathe-tools.

Casting Flange Pipe, with the ends faced true and the bolt-holes cored, was done some time ago at the Straight Line Engine Co's. Works. The ends were cast against a chill. The pattern differed from the ordinary pipe-pattern in having movable flanges to suit different lengths, and in having core-prints the full size of the flanges instead of the size of the bore. The flask was of the ordinary iron sort, having ends adjustable at intervals of a couple of inches, and with openings in the ends equal to the size of the core-prints. The core-bar was an inch or two smaller than the pipe-bore, having circular flanges or collars one and one-half or two inches apart, and four ribs throughout its length. These ribs were turned true and to a given size, and on the bar were fitted two chills set in any position to suit the length of pipe desired. The faces were recessed to form a facing for the packing on the finished pipe, and as many holes as there were to be bolt-holes in the flange were bored clear through the chill, accurately spaced and reamed slightly tapering. The outsides of the chills were turned to the same size as the prints on the pattern, except that there was left on the outside a small projection about one-eighth inch high. The chills, when on the bar, formed journals so that when rested in proper bearings the core-bar might be rotated. Common molding-sand was used for the core, and when swept up it was trued. When the flask was rammed up and the pattern removed, both ends were open to the full size of the flange. When the core was set the chills closed up the ends except the holes for the bolt-cores; and the projecting V ribs pressed into the sand and made a stop to keep the iron from running out. Cores of the size of the bolt-holes and three or four inches long were passed through the chills until they struck the green sand, so that when the pipes were cast the bolt-holes were more nearly perfect than the ordinary drilled holes. The bolt-hole cores were made in blocks like the cylinder of a revolver, in which the cores were made and baked.

Painting Iron Stacks. It is a problem which comes to almost every shop-owner some time or other, how to paint an iron stack—particularly if it is a light one and not very well guyed. The difficulty is sometimes increased by the stack being hot at the time of painting; but that is more a matter of detail with the paint and brushes if the mechanical details are right.

Planting ladders against the stack itself is usually out of the question; the rope-ladder business is not always effective even if there are hand-holds to enable one to get to the top; and scaffolding costs too much to be considered for a minute.

The rig here rudely outlined consists of a ladder a little longer than the stack is high, a stout rope about three times as long as the ladder; two stakes to keep the ladder from slipping at the foot, a stout board for the painter to stand on (or an old arm-chair without

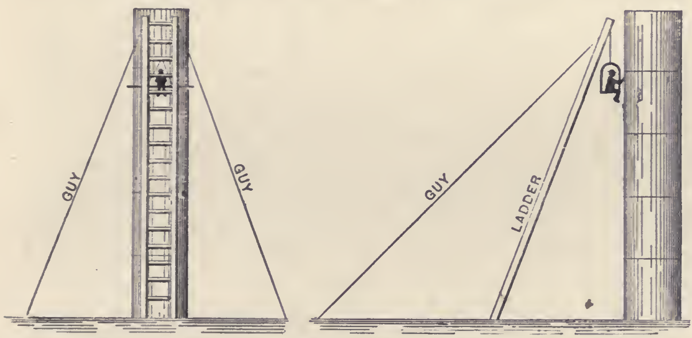


FIG. 145.—RIG FOR PAINTING IRON STACKS.

any legs will answer if it is well wired together) and a rope by which to suspend the plank or chair. It is desirable to have two ∩-shaped bails by which to hang the plank, one at each end.

The ladder is planted so that its top will come about two feet from the stack, when the strain is on it by reason of the weight; the guy-rope controlling that. The hight of suspension of the plank or chair is regulated by the painter himself, the rope playing freely on the top rung of the ladder ; or there may be a pulley-block at each end if desired.

At each planting of the ladder, about one-quarter to one-third of the stack may be reached by the painter ; after that the ladder must be shifted.

As regards the paint used—there are several compositions sold for that purpose ; and some use coarse black-lead, just such as is used for stove-polish, mixed up with turpentine and oil ; or paint first with tar and then rub in black-lead.

How To Paint Iron Work. That man who is painting those bridge-sections should have his brush full of paint slapped across his face as a reminder. He is doing work that will fail and be to your discredit. He has not taken off the scale and rust, as he should have done, with a stiff wire scratch-brush. As the paint is only to preserve the work in shipment it would be better not to use paint at all, but to swab the pieces with linseed oil and then work it in well with a stiff brush. The little pieces might be soaked in boiled oil.

Anti-Rust Compound for Bright Work. So you are going to close the establishment for awhile until these labor troubles are over? Well, no one knows how long that will be. You might as well make provision for not having the engines and machinery rust. Smear the bright places with a mixture of one ounce of gum-camphor, melted in a pound of lard, with a little black-lead.

Hardness vs. Toughness. There is one thing that machinists and other mechanics should learn, and which not one in twenty ever has learned ; that there is a difference between hardness and toughness, and that while a cutting-tool may not be tough enough, or may be properly designed and made, it cannot be too hard; and, in fact, no tool was ever yet made that was really hard enough. The fact that a tool crumbles or breaks is no indication that it is too hard; but is merely an indication that it is too brittle, or that for a given degree of brittleness it has been given the wrong lines, or presented at a wrong angle to the work, or that the work has been given the wrong speed. Or, what is less often considered, the material may have been so worked that its grain runs in the wrong direction; and any flaw which if axial would do no injury or would be expected and provided for, might be presented at an angle to the length of the tool, and thus permit it to be damaged. But taking all things into consideration, designing the tool properly in the first place, then making it from steel that has not been worked askew, and next using it properly in the machine or elsewhere, there is no extra degree of hardness that will not be desirable and profitable.

Warping of Long Tools. There is much trouble with the warping or the twisting of long tools, such as taps and reamers, in hardening and tempering. If you can so manage it as to retain a soft center there will be, or need be, but little difficulty in overcoming the warp. This is at least true of the large ones, which have a larger proportion of soft core than those of smaller cross-section. With these last, as indeed in all, it is well to be sure that you lower the tool perfectly squarely into the quenching-bath, so that the heat will be absorbed equally from all sides; and this tendency will be increased if you will try to lower the tool as far as you can in the center of the bath.

If this is true of the hardening-bath, it is equally so of the heating-bath, where melted lead or other liquid is used for heating. There will be no use in taking the trouble to cool a tool equally, if it has been heated unequally. For this reason, tools should be immersed squarely and centrally into the heating-bath, and turned around; and the turning process will also be found desirable in quenching.

Tempering Steel by Gas. Those who use a gas-burner for tempering steel should remember that there are parts of the flame which are about ten times as hot as others; and it would be well to note where these parts are for each particular burner, in order to save time in making mis-heats. A piece of an arc-light carbon serves excellently well as an indication, noting the time required to heat it to a given color and in various parts of the flame, with the gas-cock open a given distance; or, what is better yet, as the pressure in the pipe varies according to the time of the day and the demand for gas, with the flame always at a given hight, which will assure a practically-constant gas-consumption.

Where a piece is of several diameters or thicknesses in various portions, and an even hardness is desired all over, it will be well, where possible, to put the largest parts in those portions of the flame which your experience has shown to be the hottest; and the same knowledge may be made use of where the temper is desired to be harder in some parts than in others.

To hold small articles, as drills, which are to be hardened in a gas flame, it is well to make yourself some self-closing pincers of wire, giving the wire one or more turns at what will be the pivot or center of opening, and flattening it out on both parallel ends, with the flat of one end at right angles to that on the other; then filing a few nicks in that one of the flattened ends which meets the other edgewise, you will be able to hold with firmness any small cylindrical article which will enter the nick.

Blazing off Springs. Cottonseed oil will be found a desirable medium for blazing off springs. For some work a mixture of this and fish oil is preferable to either of the two oils alone. Experience alone with each class of work will determine just which oil or what proportion of a mixture of the two to use.

Hardening Tool-Steel. If you buy tool-steel from a reputable maker, and receive with it instructions or advice to harden it at a low red or any other temperature or condition, take the advice. That manufacturer is interested in making his particular steel do good service, so that he shall get your continued orders. There are reasons which you cannot explain, and which, perhaps, the makers of the steel cannot explain, either why two steels for the same purpose require to be hardened at different temperatures and colors; you had better accept the fact and make the most money you can out of it. In the same way if you buy emery-wheels of a certain brand, and are recommended to use soft free-cutting wheels for one job and hard wheels for another, take the maker's advice. Each maker wants to get his wheels to remove as many ounces of metal for you, with a given expenditure of time and power, as is possible; and most of the large establishments have made experiments which enable them to tell what their wheels will do and what they will not do. You should also take the advice of emery-wheel makers about the speeds at which to run their wheels. I do not carry this into the domain of saws, because often the makers of saws are too confident or too timid. They have not the facilities for knowing what speeds of rotation and feed will do the best service; no saws are made in the lumber regions, and few even near them. But when it comes to emery-wheels, nearly all of them are made right within the reach of machine-shops which use them, and they are in position to hear complaints very quickly and to investigate their causes and apply or suggest the remedies.

Hardening Cutters. Cutter-bits to be used in toolholders in lathes should be regularly hardened when they get soft at their lower end. It is an easy matter to lay them one side when they get a bit soft; then when enough of them are ready to be hardened they can be put into a small oven and heated a dull red; the end of each then plunged into a perforated iron box, the bottom of which is covered with just the required depth of water to harden them as far up as it is desired that they should be. Next they go to the grindstone to be ground and given out with the new cutters. Steel of high quality for such cutters should be kept out of the smith's fire.

Hardening Small Saws, such as are used for slotting screw-heads, should not be difficult, and is best effected by pressing them between two thick well-oiled cold slabs, as of cast-iron.

Deforming Dies in Hardening. In hardening, steel drop-dies usually turn out bulging in the center by reason of the strain which unequal cooling produces in them.

There are two ways of getting around this—one to grind out the bulge, and the other to make allowance for it beforehand, by leaving in the face a sink about equal to the extent of the expected bulge. This latter way is for some reasons not so good as the first—partly because it requires that one make two or more sets of dies of the same size before learning the amount of bulge to provide for. But the grinding has the disadvantage that it removes the skin of the die, which is the best part, and leaves it with its surface of unequal hardness—usually softer where it has been ground away than elsewhere, and if it has been ground all over, but more in the center than at the edges, it will be of varying hardness all the way across. This difference in the hardness may be increased by too rapid grinding or too hard a wheel, drawing the temperature of the die by the heat of the wheel.

The only advantage of the bulging-in dies is the less liability of their being broken if carelessly allowed to come together with nothing between them.

Straightening Warped Pieces. Too much hammering will make a saw-blade lose its elasticity; but it may be made elastic again without re-hardening by re-heating to a spring temper. This principle may be employed for other kinds of articles.

Hardening Around a Hole. Ring gages and such like should be hard around the hole and soft elsewhere. This may be done by clamping them between flanges on the ends of tubes through which cold water or brine is circulated; the water hardens the walls of the hole out as far as the inside edges of the flanges.

Over-Hard Tap-Blanks. Where a tap-blank that has been supposed to be annealed enough for thread-cutting proves too hard, from improper annealing or from not knowing the nature of the steel or of the heat, it is usually better in every way to anneal it over again, than to go on and wear out tools and lose temper, cutting the thread on the too hard material. It will often be best to turn it up rough, and to clean out the centers, before the second annealing.

Temperature-Gage for Steel. In order to show just how hot steel is that is being annealed in a muffle or box, supply some one-fourth inch rods, which may be pulled out from time to time to test the temperature.

To Blue Steel without heating, apply nitric acid; then wipe off the acid, clean, oil and burnish.

Working-Lines on Steel Pieces. Instead of blueing those steel pieces by heat in order to permit the lines marked on them to be plainly seen, it would be much better if you would copper the surface by rubbing it with a saturated solution of sulphate of copper (blue vitriol; blue-stone) which will coat the surface with a very thin film of pure copper. If the surface is greasy or unfinished, a few drops of sulphuric acid to the ounce of solution will make it work all right.

Malleable Castings. The reason why you are not able to make good malleable-iron castings is that you are too new in the business. It would be cheaper for you to get your castings of that sort made by those who have been in the business a good while and have a good reputation in that line. Their experience has been paid for long ago; you will not have to pay for it when you order castings from them. In the early days of such work, when the malleable-iron foundries lost about one out of every three pieces that they made, the purchaser paid for the spoiled ones, whether he thought that he did or not; and probably he paid for some that were not yet spoiled but which might be at the next run, or at some other run in the future. But you are now paying for the spoiled ones that you make. If, however, you *will* insist on keeping on trying until you get matters right, you should use pig that is very free from both phosphorus and sulphur; should melt it in crucibles of from fifty to one-hundred pounds capacity, away from the air; and should pour it when it is hot enough for a drop of it, taken out on an iron bar, to burn when exposed to the oxygen of the external air. As to the cementation, there is not much mystery about it, it is more a question of judgment as to how long to keep the pieces in the oxide of iron; the proper temperature, etc. To find out how long and how hot, you will have to pay for the experience.

Annealing Steel in Open Fire. While annealing of steel is best done, perhaps, by the regular charcoal packing, there are cases (as in break-down jobs) where this cannot be resorted to; and then the machinist will be surprised if he tries it, how well he can do by simply heating in an open charcoal fire to a dull red, letting cool down naturally so that the red will not show even in the dark, and then quenching in cold water.

To Soften White or Silver Iron so that it may be drilled or chipped, put it into a steel-furnace or other converting-furnace together with a suitable quantity of ironstone, iron-ore, some of the metallic oxides, lime or any other combination of these substances reduced to powder, or any other substances capable of combining with or absorbing the carbon of the crude iron. The more or the longer the heat is applied, the more nearly malleable the iron will become.

Draftsman's Templates. Mr. Ware, head of the die department of the Ferracute Works, has many kinks which facilitate the rapid production of sketches in his department. Among them is a cardboard template representing a flat-headed bolt, full size, the notches for the threads being sharply cut so that they may be followed (first the lines from right to left and then those from left to right) by a pencil point. He has several of these, of several sizes, representing several sizes of bolts to full scale; and they come in very handy in sketching.

Handy for Draftsmen. Some of the handiest little wrinkles are least used by draftsmen. I mention two that I came across the other day, both of them convenient and neither of them generally known.

The first is an arrangement for rubbing out a single line or portion of a line without interfering with any other. It consists simply of a slit one-sixteenth inch wide, cut in a piece of hard cardboard, thus:—

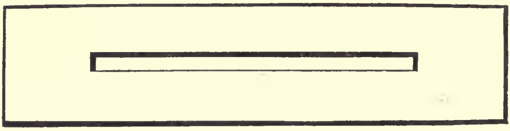


FIG. 146.—ERASING CARD.

This is used in connection with an india rubber or ink-eraser. The edges of the slit protect the adjacent lines.

The other is the use of an ordinary "medicine-dropper" (such as is used for filling stylographic pens) for loading drawing-pens. The device is very simple —simply a glass tube with a fine dropping-point, and a rubber bulb. It keeps the ink from drying, does not clog up, may be carried in the pocket if the point is tipped with a rubber cork, and saves time and ink.

Gear-Tooth Scriber. The late Mr. A. B. Couch, of the Industrial Works, Philadelphia, brought to my notice (in one of many visits in each of which I was indebted to him for some new and good idea) a scriber by which to outline epicycloid teeth for drawings or for templates. As shown in Figure 147 a portion of a wheel-pattern representing the generating-circle

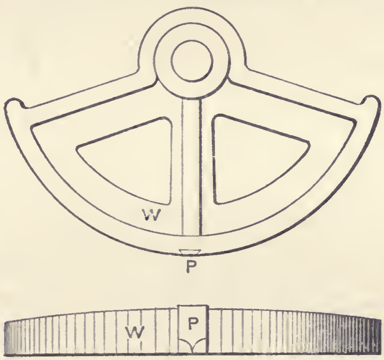


FIG. 147.—GEAR-TOOTH SCRIBER.

has a scribing-piece *P*, dovetailed with its marking-point exactly in the circumference, which is draw-filed to prevent slipping. This same wheel will draw racks, internal gears or external gears, according as it is rolled on a straight-edge, the external circumference of a solid circle, or the internal circumference of a circular ring.

Gripping T Square. In the Ferracute Works' drawing-room they employ T squares, having a spring clamping-edge, which grips a raised strip of rectangular cross-section on the left-hand edge of the drawing-board and enables the draftsman to use both hands for his triangle and pen.

Trammels may be made better with round tubing instead of a rectangular rod, for a beam, and the heads may have compression-rings set up by taper screws, so that there will be no need of set-screws. In fact, if the work is good enough, there need be little or no necessity of any clamping-device to keep the heads in their relatively proper position. No one ever thinks of requiring a clamp or other fastening-device on a pair of six-inch dividers or compasses; why should trammels need one?

The "Hyperbolograph." Well, after you have got it up, of what earthly use will it be to you or to any one? How many people in this world do you think are lying awake at nights worrying about where they can buy a machine which will draw a hyperbola with mathematical exactness? How many did you ever have to draw? How many do you expect to draw? And don't you know that you can lay one out with a pair of dividers and a parallel ruler in less time than you could rig up your "hyperbolograph" to do the same work? *Cui bono* is a good thing to remember in mechanics.

For Section-Lining Small Drawings, Mr. J. W. Payler, of Detroit, uses a small scrap from a slotting

FIG. 148.—WEIGHT FOR HOLDING DRAWINGS.

job, as shown in Figure 148, frosted, and then supplied with four very slightly raised points made by a sharp chisel so that the block shall hold the paper, but not go through it. This being set to the angle required, he places against it a taper scale made from a six-inch section of a broken two-foot rule; sometimes rising at each one-sixteenth inch advance against the corners of the weight, one one-hundredth of an inch, or according to need.

Handy Triangles. The Ferracute people use in their drawing-room large triangles having cut in them some outlines which they have to reproduce often in their rough sketches—as for instance, the heads of "hex" bolts, the conventional representation of screw-threads, etc.

Holding Large Drawings on the Board. Since going through the Pennsylvania Railway shops at Altoona, a number of years ago, I have given up the old barbarism of holding large drawings on the board by glue or by drafting-tacks, and have used small copper tacks (about the "one-ounce" size) as being cheaper and more convenient to insert and take out, and as offering no obstruction to the passage of the T square and the triangle; besides which they have not the habit, as some have, of coming up into one's thumb (whence the name of "thumb-tacks" I suppose) on being pressed into a hard board.

But in the Brown & Sharpe drawing-rooms, where I knew that they had also been using for some time the ordinary copper tacks, I saw something which they say is better yet, and which for many things is supplanting the copper tack. They use small slips of gummed paper about three-fourths of an inch or an inch long and one-fourth of an inch wide, (probably suggested by the short strips on the edge of a sheet of postage-stamps, when one is lucky enough to get stamps with some "stick'em" on them) and these make as firm a connection as is desired between the edge of the drawing or tracing and the board.

I think that it was in 1866 that I first learned to revile the memory of the inventor of the system of "double elephant" size of "egg-shell" paper (usually mounted on muslin) glued tight to the board. When a drawing was put under way there was always a margin of about one and one-half inches around allowed for the gluing, and then about another inch or inch and a-half inside that, there came a marginal line which it was the correct thing to make double, with corner pieces of greater or less complication. The outer inch and a-half of width we used for trying our drawing-pens, etc.; this part having the advantage that it was exactly the same quality as the surface on which we were to work. Thank Heaven those days have passed away, and with them the three-fourths-inch German silver "thumb-tack."

Sketching-Pads. You will find that the work of getting up ordinary sketches of machines and other work will be very much facilitated by having pads of paper faint-ruled in inch squares, sub-divided into one-eighth or one-tenth-inch squares. In repair-work many a job can be indicated better in this way than by a finished drawing; and in altering machines also, where the full lines of the original drawing would be useless as indicating processes and measurements that are through with, the mere sketch outlines, upon paper ruled to one-eighth-inch or one-tenth-inch squares would appeal at once to the eye of the workman, and not confuse him with a mass of detail upon which some other workman had been engaged years ago, and upon which no other workman will ever be engaged again while it exists.

Drawings for the Shop. In a recent example of shop-drawings, published as a guide for mechanics and draftsmen, are some very glaring faults in minor matters.

In the first place the dimension-numbers are so badly made that many of them are nearly indistinguishable. It is true that the original had been reduced from "14 x 18" to about $4\frac{1}{2}$ by something or other; but it must be remembered that to the sight of many workmen who have not on their glasses they are blurred, and to many near-sighted persons who have on concave glasses, they appear as small as they seem on the printed page mentioned, to persons with normal vision. Some of the fives look like o's, some of the nines ditto; there is a $1\frac{1}{32}$ in the upper left-hand corner which might be $1\frac{31}{32}$ with a very little imagination or very trifling visual defect; (and perhaps it really is $1\frac{31}{32}$ and looks like $1\frac{11}{32}$!) Introducing hyphens or short dashes between words, and drawing lines under them, makes them much less legible than if they were not separated and underscored; and the lines of capitals are not so distinct as "upper and lower case" would be. The example shows mongrel lettering and numbering, although the text calls for "full-face Gothic." I think that draftsmen, pattern-makers and machinists prefer "dot and dash" center lines to the full ones given in the sample drawing. Full lines for outlines of visible parts and for most hatchings, dotted lines for parts back of those which are seen, dot and dash lines for centers, and broken lines for long dimension-lines, seem to have been accepted by most draftsmen, and to be understood by most machinists, blacksmiths and pattern-makers the world over; and as the growing use of the blue-print for shop use precludes very largely the employment of color, solid red for center-lines and various tints to represent various materials seem obsolete practice. The Pennsylvania railroad and many other establishments have standard hatchings to represent certain materials; it is to be regretted that there is no uniformity in usage in this.

I show a series herewith in Figure 149.

Machine-shop drawings should be stiff and flat and never rolled. The best way to prevent this latter is to paste them on heavy tar-board or upon thin pine or poplar boards, and varnish them with white shellac varnish. It is well to varnish before the figuring and lettering are put on, so that if it be necessary to change the lettering the last coats of varnish can be sand-papered off and the lettering changed, without the lines of the drawing having to be touched.

Showing all Sides of an Object. About the most difficult inventors to understand are those who insist on showing all four sides of their inventions on one single drawing. Three sides are bad enough, yet I found a concern in Philadelphia that wanted to show the front and both sides of a large office-building in one view. But I came across a Western firm that shows both the front and the back of its machines by one photograph. It is done by placing a mirror back of the machine and having the camera at such a hight as to show the rear view directly over the front one. It is a good trick for certain classes of machinery.

Keeping Track of Drawings. In every establishment where there is a considerable number of drawings, especially in detail, and more especially where some of the sheets may be used on more than one size or kind of machine or character of construction,

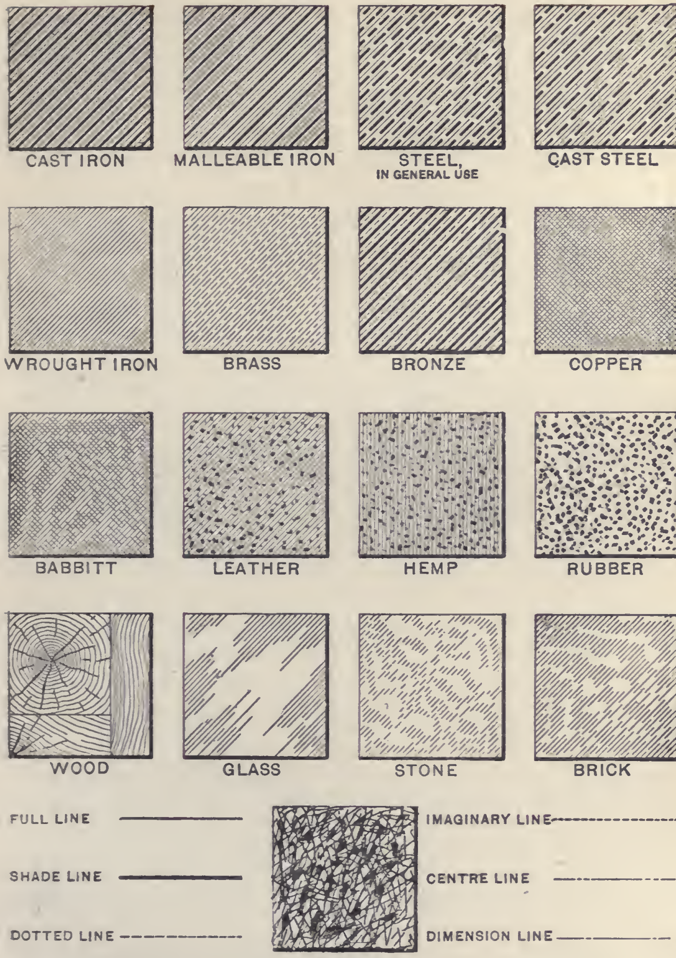


FIG. 149 —STANDARD HATCHINGS.

it is absolutely necessary to have some method by which any given drawing may be kept in but one place and found in that place when needed, or else traced to where it is in use; also that if a drawing is lent or sent away, record can be kept of its destination and of whoever is responsible for its return.

In the drawing-room of the Brown & Sharpe Manufacturing Co., at Providence, among other wrinkles is a system of card-cataloguing, similar to that in modern libraries. Every drawing, tracing or blue-print is entered on a card four and seven-eighths by two inches, with a seven-sixteenths-inch circular hole in the center of length, centered three-eighths of an inch from the bottom, hence leaving about three-thirty-seconds of an inch of card between it and the bottom edge. This is lettered as follows:—

Time No., or Name and address. | DRAWING INDEX—Brown & Sharpe Mfg. Co. Prov., R. I.

Title.

Marked Indexed under head of

Remarks,

There are three colors of cards—pink, white and light blue. If I remember rightly, all ordinary drawings are indexed on white cards, tracings on pink ones, and blue-prints on blue ones. These are strung in alphabetical order on rods which prevent their being withdrawn from the drawers in which the cards are kept; and they are never taken from the drawers. Of course, as each new card comes in, it is put in its proper alphabetical place without disturbing the others, and thus the record is always exactly complete, alphabetical and up to date.

In order to keep track of drawings that are taken from their cases or drawers, there are used cards like this:

TIME ....

....

DRAWING No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17
18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38
39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59

Note Style of Drawing	Ink Drawing	Pencil Drawing	Sketch	Blue Print		Date Delivered
White Paper				Not Mounted		
Buff "				Mounted on Cardboard		
Section "				Mounted on Wood		189
Bond "				Delivered to Mr.		
Tracing "				For Mr.		

RECORD OF DRAWING SENT FROM DRAWING-ROOM
Report if not returned within a reasonable time, or if soiled or mutilated in any way.

Each drawing as taken away from the drawing-room to go to pattern-shop, machine-shop, customer, or wherever it may be, is properly entered on one of these, which is kept as a silent witness against whoever has the drawing, until it is returned, when the card may be (and I suppose is) destroyed.

It is strange that so many shops which have a system of checks to prevent a workman forgetting to return a fifteen-cent drill-bit, should entrust a drawing worth seventy-five dollars to anyone who comes along, and without keeping any record of its delivery or return.

Curves of Long Radius. It often happens that there is a necessity for drawing curves of great radius or of making drawings having a vanishing-point which would be somewhere in the next county; and it is in the arrangement of devices by which this can be done without taking up excessive room, that the good draftsman shows himself.

Drawing large circular curves may be done on the "three-point" system, that is by taking advantage of the fact that in every circle there is any number of sets of three points each, which will be equally distant from the center; planting the three points, placing pins in the two outer ones, and swinging about them a triangular piece bearing a pencil-point in its apex, which should be at the place of the third point.

When it comes to drawing with the vanishing-point at a great distance, that can be done, not by having an excessively long T-square blade, but by cutting a wooden template to a circular curve of the desired radius, putting two or three corks on the edge of the T-square head, so as to represent three points in a similar curve, and sliding it around so as to present it at the desired angles to have all the lines converge to the desired vanishing-point.

Curve-Joining. There is a great art in curve-joining in mechanical drawing. But while there is a great art, there is very little high science. There is required the knowledge and application of just one principle; that two curves which are to touch and join each other properly must have a common tangent. Suppose that you have to draw an oval (not an elliptical) figure having a semi-circle as one portion of it, and three circular arcs for the rest; these circular arcs to join the semi-circle and each other, smoothly and without a break.

Draw a circle and across it a diameter. Use one of the two semi-circles which this gives you, for one part of the oval. Draw another diameter at right angles to the first one. Through that point where it cuts the circle, in the semi-circle which you are not going to use as a part of the oval, draw two lines across each other and of indifferent length. With each end of

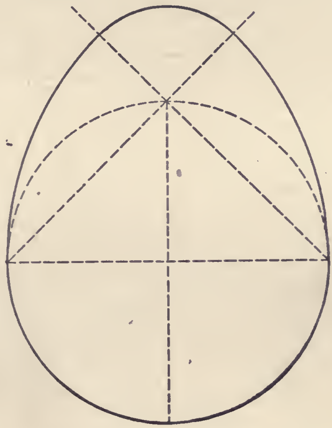


FIG. 150.—CURVE JOINING.

the first diameter as a center, draw a circular arc starting at the semi-circle and reaching just to one of the cross-lines. With their crossing-point (which is on the semi-circle not used) as a center, and with a radius reaching to where the circular arcs meet the crossing lines, draw a circular arc which will complete the oval. The first pair of circular arcs that you drew will then be tangent to the semi-circle and to the last circular arc drawn; and the oval will be smooth and symmetrical.

Equal Concentric Rings. It sometimes happens that it is desired to divide a circle into concentric rings having equal areas. Of course this can be done by dividing the area of the circle by the number of divis-

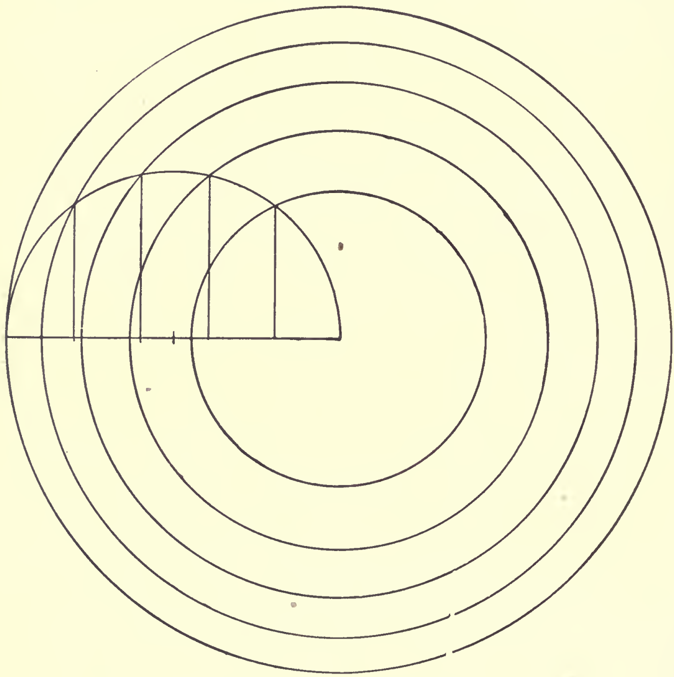


FIG. 151.—EQUAL CONCENTRIC RINGS.

ions that are required; dividing the area of each part thus found by 0.7854, and taking the square root of the quotient for the diameter of the inner circle; taking the square root of twice this for the diameter of the next circle, the square root of three times the inner diameter, for the diameter of the third circle, and so on. But the same result can be attained much more rapidly and just as accurately by dividing the radius of the circle into as many parts as there are areas required; on the entire radius as a diameter drawing a semi-circle, and at the points of division erecting perpendiculars to the radius, meeting the semi-circle in certain points. With the center of the original circle as a center, and radii reaching to the points of intersection of the perpendiculars and the semi-circle, draw concentric circles. These will be found to divide the circle into rings having equal areas with each other and with the inmost circular portion.

Erecting a Perpendicular With a Two-Foot Rule. To do this, open the rule and rest the ends against a straight edge or line, with one leg just at the point where the perpendicular is to be drawn. Then holding the other leg firmly, open the rule straight out to its full length; next join the corner which before touched the line, with the point where it touched it before, and you have a perpendicular to the straight line.

Test this the first time with a square to be sure that you connect the two proper points, and after that there should be no need of testing.

For Making Sun-Prints from Tracings, with black lines on white ground, put the tracing and the sensitized paper (the Pontrichet "gallate of iron" process gives lines which blacken with age and exposure to sunlight), put the tracing and the sensitized paper into the frame in the usual way for blue-printing, and expose to sunlight *so that the rays will fall squarely on the glass.* This is of course desirable for blue-printing also. To do this it is well to have the frame swung on horizontal trunnions and also mounted on a carriage with rollers so that it may be pointed to any quarter of the heavens and inclined at any angle to the horizon). The yellow surface of the paper will turn white. When that part under the tracing has become nearly as white as the margin, remove the print and immerse it in the developing-bath, composed of one-quarter ounce of developing-powder to each gallon of water, in an acid-proof tank or tray. The lines will turn black and the ground will clear up. When the former are dark enough, wash the print in clear water, allowing it to remain therein fifteen to thirty minutes, when you may hang it up to dry.

Under-exposure results in a more or less grayish background; while over-exposure will not give dark enough lines (burned off). The developing-bath may be used until it becomes quite black and dirty. Any dirt from it may be removed from the paper easily by a soft brush. Do not mix too much developing-solution; have the bath just deep enough to enable you to rinse the print therein, and renew it oftener.

Use very black and opaque ink for all tracings that are to be used for either blue or black-printing. The thicker the ink the better the prints from the tracings will be. If the ink is not opaque enough, add a little chrome yellow or burnt Sienna water-color.

Blue-Prints of Solid Objects. About the best way to get a working drawing of a complicated piece where the outline is very irregular or the exact shape of the curve is an important factor, is to make a blue-print from the original sample itself. The watch-makers and makers of watch-making machinery do this with great success and satisfaction.

Simplicity in Design. As an example of a complicated way of doing a thing when there is a simple one, commend me to this, sent on by an inventor who wants me to finish up the details of his suggestion. The idea is to enable a certain portion of a surface to receive less pressure than the rest, and the way it was to be accomplished, according to our ingenious inventor, is as follows: "Make a substantial box, a little larger than the surface which is to receive less pressure, with a hole near each corner, but less than the hight of the rest of the surface. Threads should be cut in these holes. Around these holes place rubber rings to act as springs. Next comes the block with corresponding holes, a little larger and countersunk. Fasten the block in the box with screw bolts, threads only a short distance up, and slipping freely through the block, but the heads keeping the block from rising higher, while the rubber permits its being pressed a little lower. Last comes the top surface-piece, the whole when completed being exactly as high as the surrounding surface. The pressure on the now elastic surrounded surface will be necessarily less than on the surrounding area. Many modifications can be made, but the above gives the idea. The extra expense when the method is once understood is comparatively small and would be resorted to only when special results are to be obtained, and then the expense is little considered or ought not to be."

To this there should be but one reply: "What is the matter with mounting the inner part on a slab of soft rubber?"

As to extra expense being of no matter, it always is of consequence; and even if it cost no more to do a thing in a complicated way than in the simple one, no inventor should ever let himself get into the habit of making a thing with ten pieces when two would suffice equally well. It is like a mechanic allowing himself to do bad work just because it is cheap. If he does poor work and makes bad fits on a cheap job his style will be spoiled, his value lessened. Go into such a shop as Pratt & Whitney's or Brown & Sharpe's, and ask them to do a rough job; you will be very politely told that their men don't know how to do it, and that they would not permit them to learn.

When you get right down to it, very often the simple methods are better than the complicated ones. Thus in taking up the lost motion of a pair of brasses, there are very few cases where it is not about as well to have liners of thin sheet iron or even of brown paper, instead of a wedge, with its attendant complication of adjusting-screws or set-screws. If an adjusting-screw has a pitch of sixteen to the inch, the range of adjustment will be, in practice, about one-five-hundredths of an inch; and that fine an adjustment may be got by adding or removing a thin piece of paper, or by substituting paper or metal of one thickness for that of another.

Simplicity in Engine Design may be carried to an extreme. For instance, it is more simple to have the guides in one piece with the engine-frame; that is, simply straight portions of the latter, planed off true. But when it comes to planing them for a second time (and with short crosshead-slides that are apt to be needed soon) the simplicity is a disadvantage, if instead of being able to take off the guide-strips and have them planed true and smooth, you must rely on some special device for planing them off in position; and perhaps that device is not to be had in your town, or you may have to pay too much for its use. The best way would be to have the frame itself planed true to receive parallel guide-strips which are reversible, as the crab-claw catch-blocks of some Corliss engines are.

"All In One Piece." While multiplicity of pieces is often a great disadvantage, yet there are times and places where it is much better to have some parts separate from others—especially where there are portions that are liable to be rendered inoperative by ordinary wear.

One of the best examples of this which I ever saw was in the case of the first pulsometers that were made, in which one of the special talking-points was that they were cast all in one piece; "no complication of parts; no costly machine-work," etc. Well, I had a mine to pump out in a hurry; the regular pumps were at the bottom of the shaft, covered four feet deep with water, and the pulsometer seemed just the way out of the trouble. It was lowered down, and did the work nobly, taking black gritty water charged with sulphuric acid just as though it had been made for that and nothing else. It was such a good thing that neighboring mines ordered some to be ready for similar emergencies. But a change came over the spirit of their dreams as to the value of such an apparatus for permanent and frequent use. "One cast shell and three ordinary cast-iron balls" sounded very well, and gave signs of an entire absence of repair-bills. But the time came when the valves and their seats wore so that the valves leaked; and then the entire apparatus was thrown out of service, because there was no way to renew the valve-seat by grinding, turning, boring or any other operation. This was remedied in later designs.

Ingenuity vs. Common Sense. Simple means are generally the best. Here you have gone and made a very expensive air-cushion to receive the shock of that reciprocating bed. You have bored out a cylinder at great expense, and turned out a piston with great expense also; but that is not enough, you must go and provide for varying the cushion, by having the bottom of the cylinder screw in and out. It probably cost you fifteen dollars to make that adjustable bottom to your cylinder. A fifteen-cent pet-cock would do the same thing just as well—better, in fact. When you want more resistance, you close it; when you want less, you open it. The adjustable-bottom cylinder is ingenious, but the pet-cock is common-sense.

The Importance of Centers. Lay out your centers! Never mind what is between them, until you see where they are. Then connect them by straight lines and lay out the positions of those lines in various phases of the revolution or other movement of the machine. If the lines cross at any time there will be no use in going any further; the centers will have to be shifted, or the plan given up.

Designing "Wrong End To." Here you are trying to make the entire plan of your machine fit the pieces that you have made. Make the pieces fit the design of the machine.

The Brace Principle. Brace it! Brace it! The triangle is the only framed form that cannot be pushed or pulled out of shape without breaking the joints or distorting the sides. The square can be worked about its joints as pivots, until it is flat and its sides inclose no area; but the triangle allows no such liberties taken with it.

Templates of the Human Figure. Mr. Oberlin Smith, who has occasion to design many special forms of presses and other machinery, in using which the workman must be enabled to use both hands and his foot at the same time to control the treadles, stock, etc., has hit upon a convenient method of enabling himself to see whether or not the various levers, treadles, etc. are at the best proper hight to be controlled by the workman without changing his general position. He has printed templates representing the human figure in profile, one-half size, and on other scales. Applying to the drawing that template which is on the same scale as the drawing itself, he can readily see whether the treadle is in position to be easily reached by the foot, whether the stroke is too great or not, etc., and in similar manner with the handles, whose position and throw can thus be settled before the drawing is completed, and made right before the machine is put in iron.

Graphical Proportion. Where it is desired to make a number of pieces in a set of various sizes, all of which have the same relation to each other in all the sizes, in keys, etc., it may be very well done by drawing by "graphical proportion" as the schools have it. For instance, suppose that there is a piece which has on it the dimensions indicated in figure by *AB*, *AC*, *AD*, *AE*, etc.; and it be required to have a smaller size with all the dimensions in the same proportion. Lay off *AB*, *AC*, etc., on a line, to which erect a perpendicular *Ab*, having the length of the piece on the smaller size which is to correspond with *AB* on the larger. Draw *Bb*; then draw *AC*, *AD*, etc.; draw, parallel to *Bb*, the lines *Cc*, *Dd*, etc., cutting *Ab* at the points *c*, *d*, etc. Then if *Ab* is the dimension on the smaller size, corresponding to *AB* on the larger, *Ac*, *Ad*, etc., will be the dimensions on the smaller one corresponding to *AC*, *AD*, etc. on the larger. Where there is a still smaller size, take on the dividers the dimensions on that third size

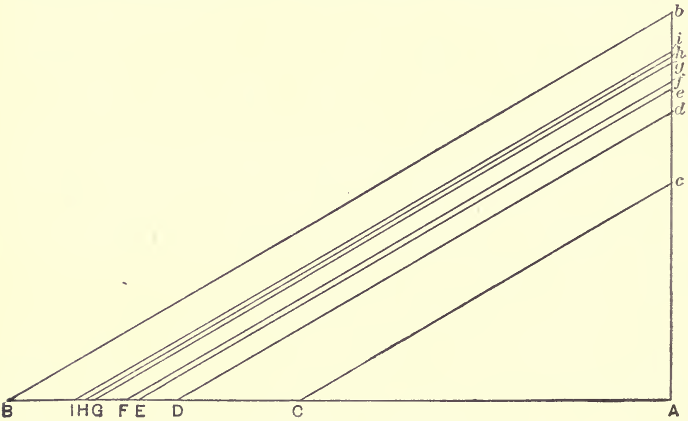


FIG. 152.—GRAPHICAL PROPORTION.

corresponding to *AB* on the original or largest size; with *A* as the center describe an arc which shall cut *Bb* at some point, which point connect with point *A*, forming a straight line. Then the lines *Cc*, *Dd*, etc. will set off on that line the dimensions corresponding to *AC*, *AD*, etc.

General Dimension Sheet. It often happens in redesigning machinery that has been changed from time to time, that there are conflicting dimensions on the various sheets; and if special care is not exercised in this particular it may turn out that a member appears to be longer inside than out; or that a journal is larger than its bearing. In order to prevent this, it is well to collect on one sheet or set of sheets all the dimensions, arranged as far as possible in their mechanical order, so that cross reference may be made with the greatest readiness, and inconsistencies or discrepancies brought out.

One good form of such dimension sheet has rulings for lengths, widths, thicknesses or diameters, and weights; and in some instances it will be found well to have a column for the number or letter of the piece, (referring to the drawings of patterns or finished parts themselves) and another for the number of each part that will be required. It may further be found convenient to have both the rough and the finished sizes and weights.

Breakages of Cast-Iron Columns. If patternmakers, molders and founders understood their business better there would be fewer breakages of cast-iron columns. Many of them give out because they have too much metal in them. It is possible by adding a molding to a column which would be strong enough, to cause it to be weak at that point, the molding drawing metal away from the interior or shell proper of the column. Leaving off the molding entirely might have just the opposite effect if it was at a jog in the diameter, as in any sharp angle there is always such an arrangement of crystals as to weaken a casting at that point. If there is any place where a molding comes other than a fillet in a sharp angle, it is best that it be made in a separate part and bolted on;—that is, where the column has to bear weight and its failure might endanger life or property.

Cast-Iron Beam-Sections. It seems strange that founders who know well enough that cast iron is much stronger in compression than in tension, and who should know that the top flange of a beam is in compression under load, and the bottom in tension, should make the two flanges equal in dimensions.

A very much better way is that invented in the long ago by Hodgkinson and shown in Figure 153;

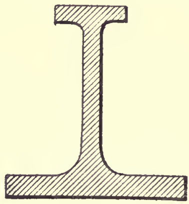


FIG. 153.—BEST SECTION FOR CAST-IRON BEAMS.

the lower flange having about five times the cross-section of the lower. With this, there is obtained greater strength for a given weight, or less weight for a given desired strength, whichever may seem most desirable. "*Verbum sap*;" which is a way the old Romans had of expressing the fact that a word to the wise is sufficient.

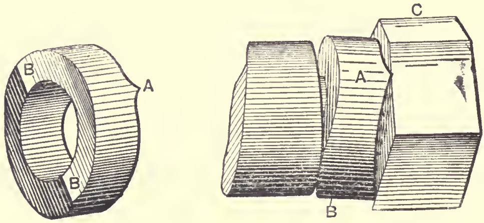
Cylindrical Nuts. Ordinary "hex" and square nuts are rather expensive to make and sometimes delay a job, they take so long to get up. After you have them, they take up a good deal more room than is sometimes convenient; and they certainly use up stock at an appalling rate. For small work it is in many cases much better to use cylindrical nuts. For three-eighths-inch bolts, cylindrical nuts three-fourths inch in diameter will replace with advantage hexagon nuts that are over seven-eighths inch from corner to corner; or square ones over an inch across corners. When of this size, they may be screwed up or taken off with a tool having jaws opening like pincers, but reamed to the nut-diameter when they are very slightly open. The nuts themselves may be produced very cheaply and rapidly by taking a steel bar of proper diameter to finish to size after turning, feeding it through a turret-lathe head, squaring the end, drilling a hole in it, running in the tap, turning the surface and cutting off the nut—all by fixed tools in the turret-head, and the cross cutting-off tool. This dispenses with all planing, milling and seating on an arbor.

In setting up such nuts there is a great advantage from the fact that the wrench may get a grip in moving through the smallest arc of a circle—instead of as with a square nut, requiring a quarter turn for a new hold, or with the "hex" nut, sixty degrees.

For large work cylindrical nuts may be cheaply produced and supplied with six or more lengthwise grooves for a spanner.

Adjustment-Nuts. In such places as on milling-machine spindles which have no back support, it is necessary to have adjustment-nuts to preserve the end position; and this adjustment must not move of its own accord. One way is to have two nuts jamming each other, turnable only by a spanner working in holes. Another is to give the main nut a taper-threaded extension, which is split in four lengths and has a taper pinch-nut to clamp it. Another way yet is to split a round nut and pinch it; and this is very good when it is split and pinched at both ends, as it gives good and even bearing all along its length. It is better to have projecting ears for the pinching-screw, as this enables the use of a wrench, which would not be the case if the screw-head were countersunk. A collar with a set-screw is a good way also—and by the way

I say my say in another place about set-screws. Where the thread is not exactly true with the spindle, a nut will bear on only one side; and to meet such cases the device shown in Figures 154 and 155 answers admirably. It consists of a washer, having at two points diametrically opposite each other, projections *A*; and 90 degrees from these on the other face, two others, *B*, *B*, *A*, *A*, meet the face of the nut, and *B*, *B* that of the arbor.



FIGS. 154 AND 155.—ADJUSTMENT-NUTS.

A nut sawed half way through at right angles to its axis may be pinched on the male thread by a small screw parallel to its axis; or the same effect may be produced by partly closing the cut with a hammer. If it is sawed nearly in two lengthwise it may be similarly closed either by a pinch-screw or by a hammer-blow, or pressure in a vise.

Improved Stud-Nut. In shops where steam-engines are built, there are a great many studs to put in; and the method in general use is to use a square nut with a set-screw in its top, and a piece of soft metal between the set-screw and the studs to prevent bruising the latter. These nuts soon become worn and loose on the studs; then the threads are so much bruised and strained that the nuts do not follow as they should. In the old Delamater Iron Works, Mr. H. S. Brown devised a stud-nut that gets over these difficulties very nicely. There is, as shown in Figure 156, a bushing with a hole tapped for the stud; then on the outside top is a thread for an outside nut to screw on; and as

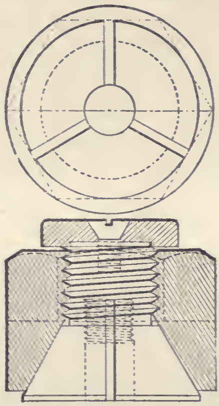


FIG. 156.—IMPROVED STUD-NUT.

it screws down on the taper bush the latter closes firmly on the stud, and prevents straining the thread. The bush is split as shown, to allow it to close on the stud. The cap on the top is to prevent the outside nut screwing off when removing the nut from the stud.

Nut-Arbor. Another form of nut-arbor is that

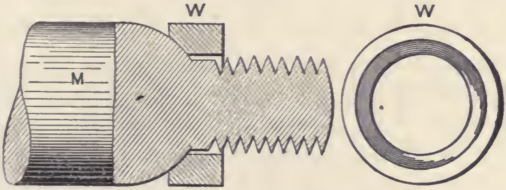


FIG. 157.—NUT-ARBOR.

shown in Figure 157; the arbor *M* having a hemispherical shoulder, to which there is fitted a cup washer *W*, that will run over and balance the nut whether it fits well or badly on the arbor-thread.

Differential-Screw Lock-Nut. In some French shops where one piece must be very securely fastened to another, as where a piston-head is to be fastened to a rod, or a propeller-hub to a shaft, they employ a nut which is threaded both externally and internally; the two threads being slightly different. There is a hexagonal part on the outside of one end of the nut, by

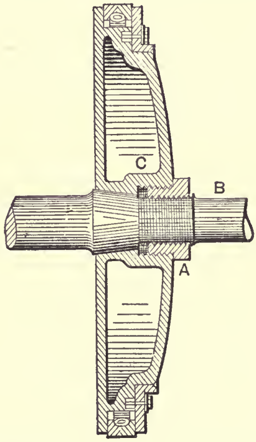


FIG. 158.—DIFFERENTIAL-SCREW LOCK-NUT ON PISTON-ROD.

which it may be turned; and the piston-head, propeller-hub, or whatever it is, is threaded to suit the outside of the nut. Turning the nut draws the rod or shaft in with a force equal to that due to the difference of the two pitches, and yet the strength is that of the coarse thread. The nut goes on the rod or shaft a few turns before entering the head or hub.

This same principle may be applied to fastening together the two parts of a connecting-rod end of the marine type, or a bollard-head on a capstan.

The Much-Neglected Fillet. Among other things that are not given so much credit and use as they should be, is the fillet, especially in right angles of jaws, housings, and similar pieces. A pattern-maker will get up a pattern for a piece which has two legs, or whatever they may be called, at right angles with each other, and one of which is subject to a stress which tends to open out the angle. If it is cast iron the crystallization in such internal angle is of a nature which will very readily permit a crack or a break. A fillet in such corner would do two things —put more metal where there is more stress and greater leverage, and do away with the crystallizing at right angles, which is the curse of all cast work. Of course, for wrought-iron work there is no trouble about the crystallizing, but the same conditions exist about the opening-out strains; they may be modified in the first place, and lessened in the second, by filleting; and in about four cases out of five the fillet would not be in the way of anything at all.

Cone-Center Pivots. The further you get away from an ordinary sixty-degree cone-center on your pivot, the further you are getting away from work that is both cheap and good. The sixty-degree angle is cheap and easy to make; the tools to make it are cheap to make, and easy to keep in proper trim; and the journal and bearing can be taken up properly without trouble.

Covers on Brass Cups. In brass-work where it is necessary to screw a cover down snugly, as on an oil-cup, there are two ways of doing—one to undercut the female thread on the inside of the cap and the other to cut one or more male threads in the body; the former will be found the best.

Taper Oscillating Valves. Those who have had trouble in making a taper oscillating valve so that it will run tight, have run across the trouble that the valve wears smaller and the seat wears larger, (which was to be expected) and even providing end take-up so as to bring the two surfaces together does not always act, because the large ends wear more than the small ones, and the valve and the seat seldom wear equally. The best way is to prevent wear rather than to provide means to take it up; and this may be done by hanging the valve on trunnions having about the same amount of taper as it has; or without taper at all, according to the materials used. Then the valve will not grind on its seat at all, and the trunnion-wear and that of its bearing can be taken up by the ordinary device of quarter-brasses, or by end-adjustment, or by other means which will suggest themselves to the designer, and the selection and application of which will depend on the circumstances.

A Good Crank-Pin for center-crank engines may be made by passing a parallel steel pin through a steel bush, placed as a distance piece between the crank-cheeks and held by a nut on each end.

Holding Things in Place. The reason why you have so much trouble with those bars swerving out of their places is that you go about it the wrong way to hold them in place. They are each held by a single screw clamping them to their place; and that screw has not a very large face to the under side of its head. The leverage is against the screw, and it lets go. One screw might do, if it had a very large flat surface to its head, so as to give it a better chance against the leverage; but it would be better to have two screws as far apart as there is room for them.

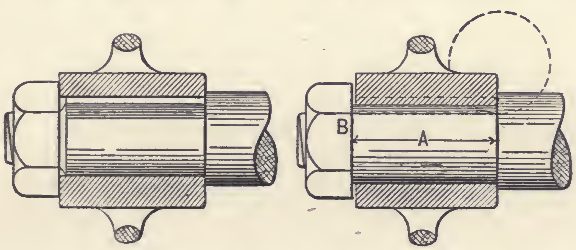
Equalizing Locomotive-Drivers. These "chats" will probably go into a good many locomotive-shops; and to some of those in these shops I want to say that there is one thing that is not often taken note of—and that is the fact that with improper equalizing between the drivers, one pair will wear tires faster than the other or others, and that this causes a loss of power and a fearful wrenching of pins. Of course, the pair that has the greater weight will wear the fastest. Then either that or the other pair will have to slip; and slipping of this character destroys tires and is death on pins; much worse than equal slipping on both pairs. So if you have an eight-wheel engine with 64,000 pounds to put on the entire wheel-set, and 48,000 of this on the two pairs of drivers, it should be considered of just as much account to have 24,000 pounds on each axle as to have the same weight on one side as on the other.

Solid vs. Spring Pistons. There is divided opinion as to the relative merits of solid and spring pistons. A solid piston is much safer than a spring piston—there is much less liability of pieces of spring getting in the ports or between the piston and the cylinder-head; but pistons and cylinder-bores will wear, and it is absolutely necessary to have some way by which the piston may be increased in size to correspond with the bore. Ordinarily there is a spider about which the rings are sprung, and a follower-plate which butts against the spider or head proper. This gives the springs a chance to expand and follow out the bore, and if the latter is "hour-glassing," they can expand and contract during each stroke. But where the cylinder-bore is parallel, it is a good plan to have the follower-plate arranged to grip the springs between it and the spider, so that when the springs are set out to the desired diameter, they may be held there until by their own wear and that of the cylinder-bore, they require to be set out by slacking up the follower.

Cut vs. Wire Nails. Just about as the people of this country are coming to the conclusion that wire nails are better than cut ones, you start to make a cut-nail machine. Why don't you keep your eyes open? If you keep on at this rate we will hear of your starting a stage-coach shop or a spinning-wheel factory. This world moves, young man; you must move with it!

To Keep Nuts from Working Loose. It often happens that it is required to hold a hub on a shaft by a nut, which would work loose unless specially prevented. This is usually accomplished by a jam-nut or other separate device; but the same thing may be done just as well by screwing the nut up against the end of the shaft (as shown in Figure 159) instead of against the hub (as shown in Figure 158). In Figure 158 the hub projects beyond the small shoulder of the shaft; in Figure 159 the latter projects beyond the hub. In both cases the end of the shaft is threaded for the nut; the only difference is that in the second way the reduced non-threaded part of the shaft is longer than the depth of the bore, instead of shorter.

Cost of Product. Did you ever try to cipher up just exactly how much any given thing that you had made, had cost? And after having done so, were you ever morally satisfied that you were right; that you had not either cheated yourself or overcharged your customer? To a certain extent you may tell how much your raw material costs; the labor on that particular job is very much easier to cipher up; but when it comes to the shop expense, where are you? That is the most variable factor in the whole business; and cost figures got up on this basis are very apt to resemble the old



FIGS. 158 AND 159.—TO KEEP NUTS FROM WORKING LOOSE.

woman's recipe for cake, in which she gives the weight of everything except one item in ounces and fractions, and then says "some" butter, or "some" ginger. One writer says "shop expense is usually determined annually by subtracting from the total expenses of the business the sum of the expenditures for raw material and labor, and dividing the balance by the annual labor cost; the resulting ratio gives the average relation of labor and shop expense for that year, and is used as a basis for the next year's cost."

There used to be a story of a man who told the weight of a pig very accurately without scales, by balancing the pig on a long pole, against a stone, and then guessing the weight of the stone.

On this basis, in a big shop the shop expense may be much greater than the labor-cost; and in a small one very much less, as regards ratio; where as a matter of fact, assuming the raw material to cost the same, the big shop should be able to have a lower labor-cost for the job than the small one. Yet, as a matter of fact, the little shop can make money at a price that would seem to mean a loss to the big one on the same job.

A better way is to regard each tool as a workman, paid so much a day; this rate being made up of the cost of power that the tool gets, the interest on its first cost, the per cent. of its value that it deteriorates each year, its share of the interest or rent of the building which protects it, and its share of the depreciation of that building. Of course, during the time that the tool is not in use, the depreciation of the building will be going on just the same as though the tool was in use; and to certain extent so will the depreciation of the tool itself; so the general expense-ratio will be rather larger for the big shop than for the small one.

Which ever way you look at it, it is a tangle; but it is better to be able to come within twenty-five per cent. of the actual cost, than only within fifty per cent.

"Cost and Ten Per Cent." Some years ago I had occasion to get some work done in a machine-shop, and it being an "experimental job" where parts had to be tried and altered, and thrown away or remade if unsuitable, the bargain was that the charge was to be "cost and ten per cent." When the bill came it created a scene. It was apparently for a large slice of the whole establishment, even though this was a large one occupying several blocks. It was about twenty per cent. higher than my own running "memos" made as the work progressed, and which I could generally rely on coming within from three to five per cent. one way or the other of the bills when they came. I demanded an itemized account, and got it—and therewith some valuable experience. For in the item of "cost" there appeared several margins of profit strictly manufacturing, together with items which seemed to me to be irrelevent and "not my funeral."

For instance, when a bright apprentice at one and one-half cents an hour was used to do work which in other shops was often entrusted to a skilled hand, I got the charge for the skilled hand. The apprentice got the practice, the firm got the profit, I got the experience. However, I really got money's worth, although it was one of my prime reasons for going to that shop with my work, that I knew their apprentices could run gear-cutters, etc., with their eyes shut (the apprentices' eyes, not the machines',) and I hoped to be charged for apprentices only.

Work done by a special department of the establishment, which was run as a special business concern, was charged at a profit to the department in which my work was done. It was "cost" to the "A" shop, but it was at a profit to the concern owning both the "A" and the "B" shops. But I had expected to get the benefit of this establishment having its own pattern-shop, foundry, etc.

But what broke my heart and ruined my temper were the following headings, which appeared among the little items of "cost:"

Interest,
Depreciation,
Wear, Tear and Repairs,
Taxes and Assessments,
Insurance,
Superintendence,
Correspondence and Accounting,
Steam for Heating,
Gas for Lighting,

and lastly,

General!

That is, I paid my share for the time during which the job was done, on all the foregoing items which entered into the debit side of the firm's ledgers. I paid not only "my share" of the interest on the building in which my work was done, but on that of the others covering the adjacent blocks and owned by the same concern. (Whether or not I paid "my share" of this and other items on the buildings, from which came the patterns and castings, on which those departments charged a profit, which were included in what was billed to me as "cost," I don't know.) I paid under the head of "general" "my share" of the wages of every clerk, foreman, fireman, sweeper and oiler employed in "my shop," and "my share" of the wages of the watchman employed to keep my work from being burned or stolen at night.

What was "my share?"

It varied each day.

If there was $3,000 worth of work done in the establishment, and of this $30 worth was mine, I paid one per cent. of the total. If it was a slack week, and there was only $300 worth done, I paid ten per cent.; but it is no more than fair to say that this never happened. Still I was glad that I was not the only customer during the few months in which my work was done.

It might be well for my readers to consider well this question of "what constitutes cost," for it concerns the manufacturer much more than it does the customer.

The firm I mention seldom lost on a contract.

Keeping Account of Shop Work is a science in itself. The system in use at the Pratt & Whitney Co.'s is worth studying. Each kind and size of machine has a number and each part other numbers; all are recorded in a book somewhat thus:—

16-INCH GRIP AND SCREW LATHE.

16-inch grip and screw lathe.

No. of Machine.	No. of Piece.	Name of Piece.
24	*3*	*Butt for Screw.*
	4	*Collar for Spindle.*
	6	*Feed and Cock Binder.*
	7	*Spindle.*
	24	*Core-Head.*
	25	*Core-Gear.*
	27	*Bush-Gear.*

The conditions of the work on each piece is indicated by marks made on this record from time to time. Thus (—) means that the piece has been forged or cast; (x) centered or chucked; (*) roughed out; (*—) nearly finished; (*—x) finished and ready to be assembled.

The time on this is kept on cards filled out by the workmen for the foreman, thus:—

Work for Geo. Q. Whitney.

For 16-inch lathes.

No. of Machine.	No. of Piece.	No. of Pieces.	Name of Pieces.
24	*5*	*60*	*Internal Gear Stud.*

Date.	Work by	Hours.	Operation.
Jan. 19.	*Tuttle.*	*5*	*Roughing.*
" *20.*	"	*10*	"
Feb. 20.	*Thompson.*	*10*	*Milling.*

Total number of hours..	....
Total cost	....
Average cost per piece.......................................	....

Consumption of Supplies. There are many shops running to-day, the proprietors of which cannot tell the cost of any one item in their production, except perhaps labor, in a general way. There are others where the cost in each item or sub-item is known to a decimal point, and where the proprietors can detect a leak or a waste the first week of its happening.

In the matter of supplies too many shops have a "go as you please" system or way. Every one is allowed to call for as much of anything as he chooses to take the trouble to go for or send for. It is easy to see that in such shops there are many opportunities not merely for waste through carelessness, but for theft.

Those establishments where the account is taken of everything that is issued to anyone, and not only that but even the amount to any one department or any one man, assure me that it pays them to do it, just as much as it pays a housekeeper to know how much butter and how much sugar are used per week and per meal and how many pieces go in the wash each time from each member of the family and how many come back.

In the Brown & Sharpe shops the system is at once simple and thorough. To commence with, in each department there is a blank, "cap" size, in which

TOOL ROOM.

No.. ..... BUILDING.

Consumption of Supplies by HELP for the four weeks ending............ ....189..

No.	Name.	Cans of Oil.				Files.				Bunches of Waste.	Sheets of Emery Cloth.		
		Lard.	Sperm.	No. 2 Cosmoline.		Bastard.	2d Cut.	Smooth.	Grobet.				

the supplies drawn by each workman are entered. The heading of one of these blanks (that for the tool-room of any one building, the number of which latter is to be filled in) is here given. If there is suddenly a big run on some one kind of supply it will be known at once, so that if any man has a trick of washing his hands with waste and lard oil, or of pocketing Grobet files, it will be apt to be traced to him pretty quickly; and also if there is an extra run on any one kind of files it will be known, so that more may be purchased in time for that particular kind of work, or perhaps the work transferred to milling-machines or emery grinders.

There is another sheet in which the returns from the various departments are entered, as turned in by each on the forms just shown. I show the heading here. In the left-hand column, headed "Supplies," appear the following items: lard oil, sperm oil, No. 1 cosmoline, No. 2 cosmoline, and naphtha; the word "gals" appearing at the head of each of the nine following columns for these; then, with the word

TOOL ROOM.

No.........Building.

Consumption of Supplies by departments for the four weeks ending............189..

Supplies.	Basement.	First Floor	Second Floor.	Third Floor.	Smith Shops.	Hardening Room.	Pattern and Flave Shops.	Foundry.	

"dozen," items bastard, second cut, smooth and Grobet files, bench, thread and tin-handle brushes; then belt-lacing (feet); next with "lbs." items solder, iron rivets, copper rivets and waste; then emery cloth (qrs.); next, with words "ft. and in." item "belting," six times. On each blank there is place for other departments or other items, should new ones be added.

Over-Time Work.—Fritz wanted to run his pattern-shop over-time last week, and he found, that in order to do it, he had to run all his main line, the whole 180 feet of the shops, although the pattern-shop is at one end and the engine between it and the rest of the establishment. So all night 150 feet of three-inch shafting was running and using up oil and babbitt-metal, just because he didn't know enough to put in a clutch even anywhere along the line. It probably took four horse-power to run that straight line of 150 feet; and while the actual cost of coal for four horse-power for ten hours ought not to be over half a dollar, and the cost of oil and babbitt on the extra line, and the extra cost of oil and babbitt on the engine, may increase it but little, the risk of some of the bearings running dry, and of something happening in the shop where no work was going on, is so great that it is foolish to take it. Moreover, if he had wanted to run his pattern-shop and change pulleys in the main shop at the same time, he could not have done it.

A clutch is a good thing.

Loss in Correcting Bad Work. I don't like to see a man spend about four dollars' worth of time and forty cents' worth of tools, in correcting work that should have been right at first. Now, for instance, there is a man who is using a round file to correct a hole that did not come fair in boring. It will take him about a day and a half to go over that particular job; he will use about forty cents' worth of file as I figure it. After he has got through he will only have a round hole, which he should have had at first; and it will not be of the diameter that was desired, but will be too large. If he had properly used the tools and jigs that are at his disposal he would have saved you the cost of his time and file, and himself the mortification (if he feels it) of having done a bad job; although what usually causes the mortification is not doing bad work, but being found out. He should no more use labor and round files to correct work in his department, than his fellow workmen should use a drift to correct bad punching in the boiler-shop.

If your man will start out and mark off two circles, one of the proper size and the other half the size of the hole to be drilled, he will find out when he has got down to the size of the smaller circle, whether he has made his start right or not; and if he has not, he can readily correct himself before he has gone far enough to do any harm; but if he waits until he gets to the full diameter of the hole, it will be too late.

The Figurer. In almost every community there is some man or other who has certain figures by which he swears under all circumstances. Sometimes the figures are right and sometimes they are wrong. More often they are right under certain conditions and "away off" under others. The worst case of figurer of which I know is the man who figures up belt-power and that sort of thing. He is of the class who rush in where angels fear to tread. It is his rule that 600 feet per minute of single-leather belting one inch wide will carry one horse-power. With him, that rule is like the laws of the Medes and Persians in that it altereth not neither is it to be changed. It makes no difference what kind of a pulley the belt runs on, nor how many degrees of arc of contact, nor whether it is a vertical or a horizontal belt, or an open one or a crossed one, nor how tight it is stretched, nor what the diameter of the smaller pulley—it is 600 feet to the horse-power and that settles it. As it often takes 1200 feet, and as sometimes 400 will do it, one can readily see that the figurer will sometimes come out wrong, and may indeed be the cause of some figuring on the wrong side of the "Profit and Loss" account in the ledger.

Another figurer is the one who needs a certain discharge of water from a given area under a given head or with a given velocity, no matter whether the opening is round or square, long and narrow, or angular; no matter whether it is tapering down or flaring, nor whether the material is rough wood, or polished iron tube; his "90 cubic feet of water with a rate of flow of two feet per second" has got to be accepted. As a matter of fact there are cases where the actual flow is only one-half of the theoretical at this speed, instead of the three-quarters which gives the rate of 90 cubic feet. But little things like that don't bother the figurer. One of them indeed had 120 cubic feet per minute through a square foot of orifice, with a flow rate of two feet per second; and when it was shown him that the maximum amount that could possibly go out at that speed, supposing that there was no friction at all between the water and the walls of the orifice, was 120 cubic feet, he acted just about like that other man, who on being shown where his statements did not coincide with the observed facts, calmly remarked "so much the worse for the facts."

All of us who figure should bear in mind that constants and rules are properly obtained from average practice, and that they are seldom invariable. Newark, N. J., is just now (December, 1895) preparing to lay a supplementary pipe-line for its water-supply, because the one already laid, with dimensions based on an erroneous constant based on the Rochester line, carries only about half to two-thirds what was expected.

Calculating Horse-Power There is no use in going up stairs for the privilege of coming down, either in walking, language, or calculation. When figuring up horse-power it is usually necessary to get at the area of the piston-head by squaring the diameter and multiplying the square by 0.7854; and then it is necessary to divide by 33,000. Now as 0.7854 ÷ 33000 = 0.0000238, that figure may be used as a direct multiplier, thus not only saving time, but lessening the chances of mistakes by substituting one operation for two.

Another good figure to remember in this connection is that 20½ inches is the diameter of a circle having an area of 330 square inches; and for an engine of this piston-diameter the horse-power at 100 lbs. per square inch mean effective pressure is equal to the piston-speed.

Net Horse-Power of Steam-Engines. About 1893 I published a rule for giving the *net* horse-power of steam-engines, allowing about 16 per cent. for friction; which is about right in most cases. As I have many times been asked for it I repeat it: Multiply the mean effective pressure in pounds per square inch by double the piston-speed in feet and by the square of the piston-diameter in inches; then point off five places from the right. Thus: an engine 10″ x 12″ at 200 turns per minute, with 50 pounds per square inch of mean effective pressure, should by this rule have a *net* horse-power of 50 x 800 x 100 = 40 (00000.) Its gross horse-power would be 50 x 78.54 x 400 ÷ 33000 =47.6

Another form of the rule for *net* horse-power, allowing about 16 per cent. for friction, is to multiply the mean effective pressure by one-fifth the piston-speed in feet and by the square of the piston-diameter, and point off four places. Thus the same engine, allowing 16 per cent. for friction, etc., would have 50 x 80 x 100 = 40 (0000) *net* horse-power.

In all engines of 12 inches bore the *gross* horse-power equals the product of the mean effective pressure and the travel in feet per minute, divided by 291.8; and the net horse-power is about equal to the mean effective pressure times thrice the piston-speed, with three figures pointed off from the right.

Thus: 12-inch engine has 40 pounds mean effective pressure, and 400 feet piston-speed: then the net horse-power equals $400 \times 1200 = 48$.

A simple formula for horse-power, which I got up in the long ago, is $P A T \div 33{,}000$; P being the mean effective pressure in pounds per square inch, A the piston-area in square inches, and T the piston-travel in feet per minute.

Pressure on Safety-Valves. Calculations aside, the pressure on a safety-valve may be determined by a good scale hooked at the point at which the valve-stem is connected with the lever. The lever being horizontal as shown in Figure 160, the pull on the scale

FIG. 160.—PRESSURE ON SAFETY-VALVES.

shows how much pressure there is exerted on the valve proper by the beam without any "pee." The pee being put in place at any desired position, the balance will indicate just what pressure the lever and pee will put on the valve. The valve being weighed separately on the same balance, and its weight added to the amount due to the lever and pee, you have the entire weight on the valve. This being divided by the area of the valve, (as taken from a table of areas of circles or figured out by multiplying the square of the diameter by 0.7854), the pressure per square inch at which the valve will blow off will be known.

Where it is desired to calculate the effect of the pee two distances should be measured, as shown in Figure 161; that (*d*) from the fulcrum to the valve-stem and that (*D*) from the fulcrum (*not* from the valve-stem) to the pee. Then in the same proportion as that between *d* and *D* will the weight of the pee be

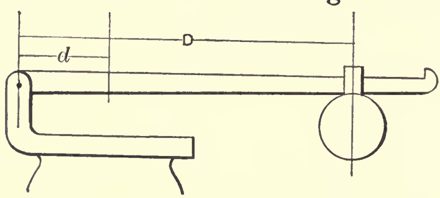


FIG. 161.—PRESSURE ON SAFETY-VALVES.

multiplied by the leverage. But it must be remembered that to this the dead weight of the valve and stem, and the multiplied pressure due to the weight of the lever, must be added. Thus, if the lever when removed and balanced in a strong loop, balances at a point distant say eighteen inches from the fulcrum, and the stem is six inches from the fulcrum, the weight of the lever will be multiplied 18 ÷ 6 equals three times, by its own leverage.

We will suppose that this is the case; that the lever weighs seven pounds, the valve and stem six, and the pee fifty; and that the pee stands at a distance *D* equal to four times *d*. Then we have for the pressure exerted by the pee 4 x 50=200 ; for that exerted by the lever 3 x 7=21, and for that exerted by the valve and stem 6 ; total pressure 200 + 21 + 6=227 pounds.

Finding the Center of Gravity. You sometimes need to find the center of gravity of an irregular figure. If it is a piece of regular thickness, cut out its outline in stout pasteboard of regular quality throughout, and then stick a needle squarely through it about where you think the center should be, until you find a place at which it will stay in any position in which you place it, when the needle is held horizontal and the hole is large enough to let the piece turn freely.

Another way is to make a little plumb-bob of a thread and a bullet and hang it from the needle when the latter is stuck in two places near the periphery of the card. Where the lines cross will be the center of gravity.

Atmospheric Pressure. The pressure of the atmosphere is given in text-books, engineers' pocket-books, etc., as all sorts of things from 14.7 pounds per square inch each way. So many different decimals are given that sometimes it is difficult to check off the accuracy of a result or of a formula.

The International Bureau of Weights and Measures, and the U. S. Coast Survey, use as their figure for reduction, a standard of pressure representing that of a column of mercury 760 mm high, at a temperature of 0° C equals 32° F, at sea-level in latitude 45°. Under these circumstances a column of mercury is balanced by a column of air weighing 14.697 pounds per square inch. This value is derived thus:

13.5956 (density of mercury) x 76 x 6.4517 x .00220462 equals 14.697.

Anchoring Beams to Blocks is often called for; and when done it should be done "for keeps." One very good way emanating from Sibley College in its early days shows how it may be done by a taper plug having its largest diameter just equal to the hole drilled in the rock, and a gas-pipe of the same diam-

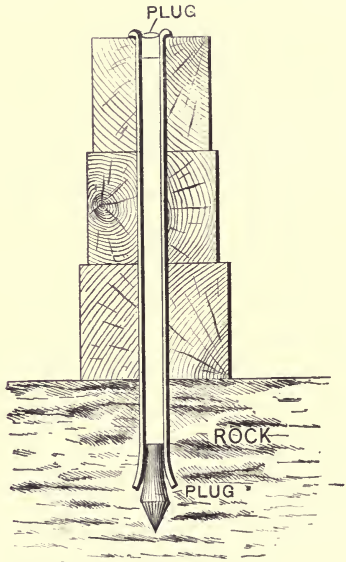
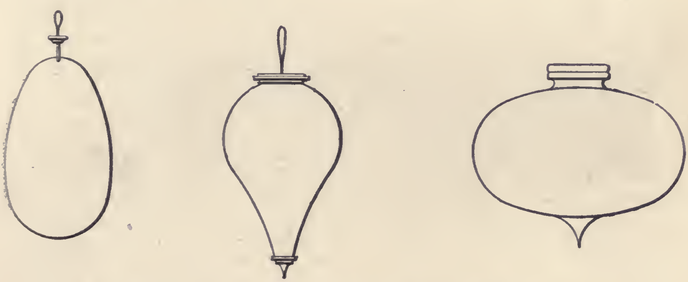


FIG. 162.—ANCHORING BEAMS TO ROCKS. (SWEET.)

eter. The plug being dropped or pushed into the hole in the rock, the latter having been drilled and the timbers bored to the same diameter as the outside of the pipe, the tube is then driven down, and when it finds the plug its lower end is expanded into the rock so that it will be larger than the hole above.

The upper end of the pipe may be expanded and turned over as shown in the sketch.

Plumb-Bobs are seldom if ever made of the right shape to insure their coming to rest soon. They are usually made of pear shape with the string where the stem would be; or when they are intended to indicate a point underneath them, instead of a line alongside of the line, they are top-shaped with a sharp spike. In the former case the swinging is stopped in the least possible time permissible with such a bob, by letting it hang in a pail of water or very thin mud, or some other liquid.



FIGS. 163 TO 165.—FORMS OF PLUMB-BOBS.

But both of these forms are all wrong. Any body tends to rotate about its shorter axis; and if not hung in this line it will not make any difference, but will wabble about and try to assume that line. That this is a fact, any school-boy who has attended lectures on physics, and seen a whirling-machine cause a chain ring hung by one edge to flatten out and revolve about an imaginary axis, can attest. Now the plumb-bob should be turnip-shaped, so that it can be hung on its shortest axis; and then all the whirling that it can undertake will not make this axis swerve from a vertical line. If for ordinary use in plumbing columns, etc., it needs no points; but if it is to be hung so as to point to a particular spot on the ground it should have a spike as a prolongation of this shorter axis.

Plumb-Bob Lines may be readily reeled up by using the cheapest kind of fishing-rod reel on a short pine stick. It is just as good as though it cost forty dollars.

Plumb-Bob Tips screwed to the body of the bob may have a milled flange about half an inch from the butt end, and a thread cut on both sides of this flange, so that when the bob is not in use the point may be unscrewed and turned into the body of the bob, thus lessening the room required and diminishing the chance of injury to the point.

To Press in Connecting-Rod Bushings, driving-box brasses, etc., it is well to have some stirrups made of about two to two-and-a half inches square steel, the legs to be drilled with seven-eighths-inch to one-inch holes about three inches apart; these stirrups to be passed through holes in a cast-iron base about one and one-half by two feet square. The jack being set on the base and the driving-box, connecting-rod or other piece against the stirrup, a common jack may be introduced and the work done with neatness and dispatch. The various pairs of holes in the stirrup-piece will enable holding work of different dimensions without changing stirrups, and without working the jack too far. Any slight difference in dimension may be taken up by a shim, so that there need not be too much pumping.

Disconnecting a Piston-Rod. Jake Damphool, down at the Vulcan Works, disconnected the piston-rod of their engine, which was screwed into the crosshead, by a pair of pipe-tongs; and a pretty-looking rod he had of it, after he had got through. Will Wide-awake, over at the Etna Works, clamped two pieces of hardwood together with a piece of pasteboard between them, described on their ends a circle of the diameter of the piston-rod, sawed that out, and thus had a clamp on which he could use a long wrench. You had better try his plan; and before you replace the rod give the thread a good coating of graphite and oil, and it will run in more easily; then the next time you want to disconnect you will find it give only about one-half the trouble.

For Removing Piston-Rods from Crossheads where they have got too firmly seated, it is convenient to have a small hydraulic ram such as is used in some railway shops. But there are many places where such work is done so seldom that there is no use in investing in the ram; and again many rods have to be removed in place, and the ram is not always handy. For such work it is often best to have a short piece of crop-end of shafting, with an inch hole bored nearly all the way through its length, and having at right angles to this a slot (say an inch wide by two inches long for a three-inch piece of shafting) extending clear through. In the lengthwise hole place a steel cylinder five-sixteenths-inches in diameter, (or the crop-end of so-called ⅞-in. rod or iron shafting, in default of anything better) of a length sufficient to reach from the end of the large block, to the cross slot. This is the plunger, and the large block is the cylinder of this mechanical ram, the power of which is to be gained by a wedge. Placing this between the rod-end and the wrist-pin, and putting between its end and the pin a packing-piece of copper, the rod may be forced out by a well black-leaded steel wedge of slight taper—the slighter the taper the more easily the work is done.

A Driving-Block, such as is shown in Figure 166, has a solid foundation, and may be used for driving out spindles whether they be one-half or four inches in diameter. The opening is V-shaped and the face plain. By reversing it there is presented a good anvil for straightening shafting.

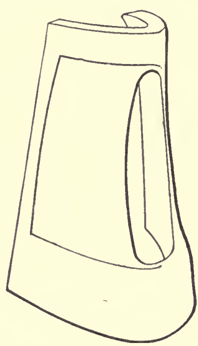


FIG. 166.—DRIVING-BLOCK.

The cost is but slight; the room which it takes up insignificant; while the number of times when it will prove serviceable makes it well worth its keep. It should be of good tough cast iron and free from sharp re-entrant angles. The sketch shows sufficiently clearly how it may be given great strength to resist blows with comparatively little weight.

Drift for Arbors. Drifting arbors is no fun if the drift happens to slip, as by a foul blow. The liability of this happening is very much lessened by the

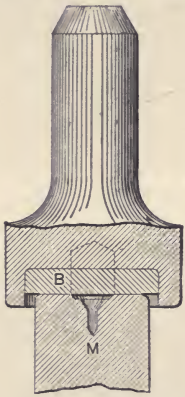
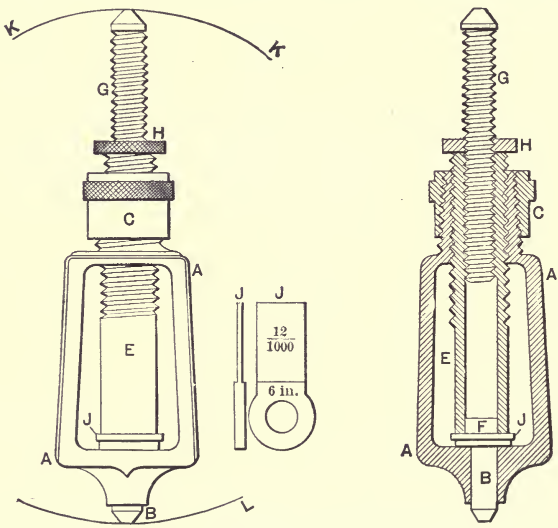


FIG. 167.—DRIFT FOR ARBORS.

device shown in Figure 167, *B* being a babbitt-metal disk, the thickness of which is less than the depth of the recess in which it fits.

A Shrinkage-Gage which was brought out at the Hartford Steam Engineering Co'.s Works should prove handy. As shown in Figures 168 and 169, *A* is a frame having at its lower end a fixed measuring-piece *B*, and at its upper end a thread and taper split hub, receiving externally a taper-threaded screw cap *C* and internally a tube *E*, having at its bottom a fixed plug *F*. The adjustable measuring-leg is threaded with the tube *E*, so as to be adjustable for various diameters of boxes, but may be locked by the jam-nut *H*. The cap-nut *C* and jam-nut *H* once loosened and screwed back, allowing the stem *G* and the tube

E to be adjusted to the exact size of the shaft for which a shrinkage fit is to be bored, the cap-end *C* and jam-nut *H* are screwed home; the nut *C* drawing the split hub of the tube *E*, so that the shaft measurement is made with all the lost motion of the device taken into account. Then *C* is loosened, *E*



FIGS. 168 AND 169.—SHRINKAGE-GAGE. (HARTFORD S. E. CO.)

raised up by turning to admit a shrinkage-gage piece *J*, Figure 169, the thickness of which equals the amount to be allowed for the size of bore to be shrunk on the shaft. *J* being inserted, *E* is turned back so as to bind *J* between the end *E* and the flat piece *B*, when *C* is screwed down, again clamping *E*.

Erection-Blocks. In every large shop where heavy machinery is erected, there is felt the necessity of some way of giving the machines a firm, solid foundation during erection, and often during test also. It would be impossible to have the entire shop floor so solid as to do away with the necessity for special foundations, and it is expensive to build these even temporarily. In the Bement & Miles shops they employ "erection-blocks" of cast iron, say six feet long, and twelve inches by nine on the end, cored out to lighten them, and planed over all four sides. Combinations of these are much better than wooden balks, as they have the advantage of being of absolute standard size, and of affording an even bearing all over their surfaces; also they permit various combinations of hight which may be convenient where certain under portions of the machines in course of erection are higher than others.

To supplement their use there are also very short screw-jacks, which aid in supporting portions of the machines which could not be brought to a bearing on long blocks, or which might not be an even multiple of twelve or nine inches from the floor.

Hydraulic Fits. In the fine shops of the H. Bollinckx Co., in Brussels, Belgium, (where the present manager, Mr. Arthur Bollinckx, is in his make-up, about as near an approach to a New England Yankee as anyone I have found in that bustling, practical little kingdom,) they have an excellent way of attaining two desirable objects in making jacketed steam-cylinders for Corliss engines. The cylinder proper is cast with one pair of "nozzles" for the valves of one end, the other end being the "pipe" or "runner" end. The jacket is cast with the other pair of nozzles, for the valves of the other end of the engine; the other end of this casting being the sinking-head.

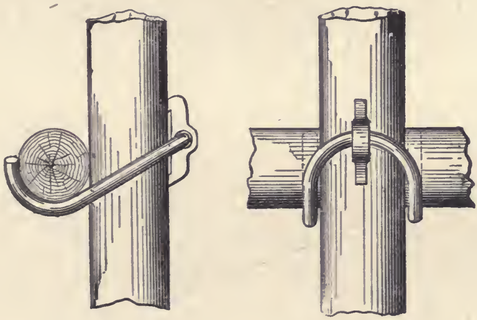
Then both sinking-heads are cut off and the two castings are made to fit each other "metal to metal," being forced together hydraulically. Thus we have cylinders with no honey-combs in either the bushing or cylinder proper, or the jacket; there are no leaky joints; and no cores can float out of place and afford the steam insufficient passage-way—as sometimes happens when a chaplet fetches loose in our ordinary system of making these same things.

Screwing Pieces Together. The ordinary practice of laying out and doing work, where one piece has to be fastened to another by two or more screws, is to lay out the centers for the bolt-holes and tap-holes by cross-marks which are then prick-punched; and the holes are next drilled and tapped. The holes may or may not be accurately spaced, so that the pieces go together with greater or less difficulty; and sometimes one screw pulls one way and another in another direction. Then, according as one or the other screw is tightened first, the part assumes different positions. If the holes are made considerably too large, there may perhaps be less trouble about assembling, but more as regards the firmness of the machine when put together.

In the Bilgram shops, in Philadelphia, the practice is much better than this. There only one of the tap-holes is tapped at first; then screwing the part to be held in place by this one screw, the remaining holes are tapped, letting the full-sized holes act as guides for the tap.

This method of procedure takes a little longer at first, but in the end it pays by reason of the superior accuracy of the work.

Scaffold-Dogs. Where round timbers are used, it is rather more difficult to make scaffolds than where square ones are available. But our neighbors across the water make use sometimes of dogs, by which quite large poles may be rapidly and securely clamped together and very readily taken down when desired. As shown in Figures 170 and 171, there is a U-shaped piece of round iron, the free ends of which are bent



FIGS. 170 AND 171.—SCAFFOLD-DOGS.

round so that it may be described as a U-shaped hook or a hooked U. Its bow is passed through a double dog having downwardly-projecting teeth which may be driven into the vertical member. The horizontal timber being laid in the upturned arms of the U-shaped hook as shown in Figure 170, the greater the weight brought on the hook the more firmly the teeth of the dog are driven into the vertical timber.

Ladder Scaffold-Bracket. I have been putting up some scaffolding, and using ordinary short ladders as the uprights. This is the way it is done: The plank upon which the men work is supported by $1\frac{1}{2} \times 1\frac{1}{2} \times \frac{1}{2}$ inch T-angle irons *D*, bent at one end

G, to half encircle the ladder-round *B*, and at the other end *F*, turned up and perforated with a 7-16 inch hole. A strap *E*, $1\frac{1}{2} \times \frac{3}{8}$ inches, is twisted and bent so as to half encircle the rung *C*, and has at its other end a number of 7-16 inch holes, in line, so as to permit the plank to be kept in cross level, no matter what the inclination of the side-pieces *A*. Pins 7-16-inch in diameter with heads and split cotters connect *E* with *D* at *F*. There is at each end of the plank a piece similar to *D*, fastened there by four long flush-

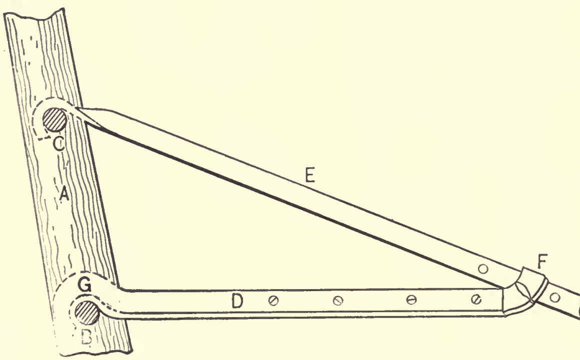
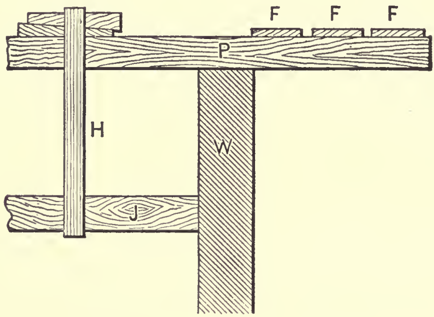


Fig. 172.—Ladder Scaffold-Bracket.

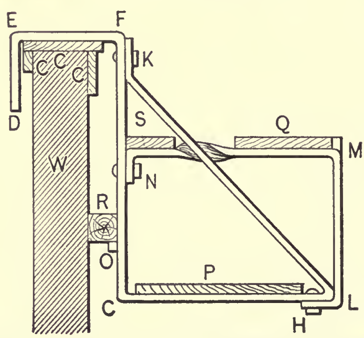
screws; the plank resting also on the flanges of the *T's*. About a foot from each end there is another piece similar in outline to *D* but made of plain strap, $1\frac{1}{2} \times \frac{1}{2}$ inches, bent as at *G* and as at *F*, but twisted so as to present the flat side to the under surface of the board. Four short flush-screws fix each of these to the board at such distance from *D* as to bring the straps at the ends of the rounds where the latter are strongest against shearing. In the sketch, *G* is shown hooked to the next round above the one on which *D* rests; but there should be length enough of *E* to permit it being hooked to the round next but one above *B*.

Stagings. In these days of towering buildings a fall from a scaffolding or staging means more than it did when three, or at most, four stories was the limit; and care should be taken to have the supports of the strongest character, while ease of putting up and taking down, as well as cheapness, be not forgotten. It may be taken for granted that the old way of cutting or leaving holes in the walls, through which to pass joists, has about passed away; also that the erection of a forest of rough boards and round or square timber, nailed, bolted or lashed together in a crude manner, is not in accord with the spirit of metropolitan constructive art. Staging for brick-layers requires to be strong, stiff and light, and must be of a character to be easily put up and taken down by unskilled laborers. Assuming that a wall has been run just past the second floor line—say to the window-sills; the joists, of course, being in their place, what is the best way to put up staging to accommodate the men and materials? One way is as shown in Figure 173, in which *W* is the wall, *J* one of the joists under a window, *P* a 3 x 10-inch, or better yet, a 3 x 12-inch piece, one of several which are to support the 1½-inch boards *F*, which constitute the staging floor. A double hook *H*, shown separately in Figure 174, is made of strap or bar iron three inches wide, one-half inch thick; slipped under the joist *J*, and held while the plank *P* is slipped under its upper end; wedges are driven in to bring *P* level, and the plank is then ready to receive the weight. The hooks should be forged so as to take in the joists and planks snugly.



ONE WAY OF PUTTING UP A STAGING

VIEW OF DOUBLE HOOK



ANOTHER METHOD OF SUPPORTING A STAGING

FIGS. 172, 173, 174.—STAGINGS.

If there is any lateral looseness, a wedge should be driven in to keep the planks *P* from rocking. Trestles may be put on the floor *F*, if desired, but never rested on bricks, as is a common custom, in order to gain a couple of inches.

Another method of hanging or supporting external stagings is shown in Figure 175, in which the line *D E F G H K* represents an iron bar 1 x 3 inches, bent as shown, and *L M N* another, bent and twisted in the line indicated and bolted to the other, if desired. Omitting *L M N*, the bar *D E F G H* makes a good hanger, which may be hooked in the window, *W* representing the wall and *C* the casings. The plank *P* serves as a staging for painters, pointers and other workmen who do not require hods of material to be brought to them. *Q* gives a higher reach if desired. An off-set *M* prevents the plank *Q* being displaced laterally, and another, *O*, serves as a rest for whatever blocking, *R*, may be required to keep the hanger vertical when affixed to a wall thinner than the maximum to which it can be applied. If desired, *L M N* may be of sufficient length between *L* and *M* to raise the plank *Q* to the level of *K*; the same bolt going clear through three thicknesses instead of two. This will give a "second reach" considerably higher than that shown in the illustration at *Q*. The hanger as arranged may be used to support trestles, a narrow plank *S* being inserted for that purpose. Instead of the twist in the line *M N*, there may be one in *K L*, which will allow a wider board to be used at *Q*; or there may be lateral off-sets, without twists, in both *K L* and *M N*; those in every strap similar to *M N* being, say, to the right, as viewed from *M*, and those in all similar to *K L* being to the left, as viewed from the same point.

Common Sense in Arrangement. One day I was much struck by a very great waste of time and labor which was taking place at the entrance of an immense establishment, and probably was an indication of other wastes which were going on within.

There were being discharged from a truck at the door, a number of large packages which weighed from seven hundred to nine hundred pounds each, and were not handy to lift or carry. Each of these had to be weighed and its number and gross weight noted, before being put upon the elevator and taken upstairs. The position of the doorway, scales and elevator are as indicated by Figure 176;

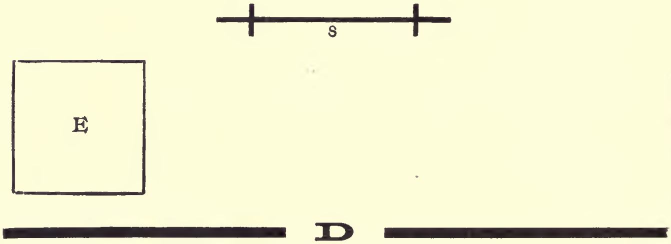


FIG. 176.—WRONG ARRANGEMENT.

D being the doorway, *E* the elevator and *S* the scales. Every package on being rolled in from the truck was taken from *D* to *S*, and then packed and turned so that it might be run on the elevator, which was capable of taking several of them at once. The doorway was ample, and there was plenty of room all round for any disposition that might have seemed the most practical.

Had I been doing that job I should have arranged it about as follows:—running the packages in from the doorway to the scales at once, then keeping on with them under the scales and to the elevator platform. This was an establishment in which there was a constant stream of tierces and cases, each of which had to be weighed, and all of which came in at the same door, and went up the same elevator. Why the

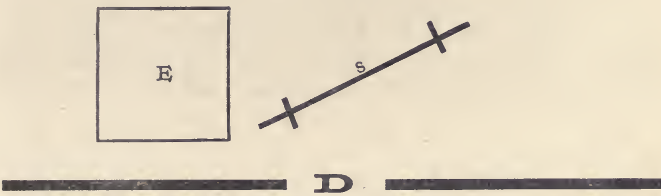


FIG. 177.—BETTER ARRANGEMENT.

scales should have been put in the dark, beyond the elevator, and the packages and tierces taken back on their track, is beyond me.

The former arrangement strikes me as not at all practical.

Cranes and Their Kin. Every now and then I see some establishment or other stalled with its crane unable to lift a load, which the crane itself is strong enough to hold up, but which the hoisting-gear is not powerful enough to raise or control. This leads me to point out some ways by which as long as the structure itself—the mast, the boom, and the rest of its framing—is strong enough, as well as the building to which it is fixed, if it is so fastened, the lifting-power of the gears may be increased.

Once in a while with hand cranes, this is done by having instead of the ordinarily-used spur and pinion, another pair having greater pitch-ratio. Thus, if there is for "every-day" use a thirty-six-inch spur served by an eight-inch pinion, making four and one-half to one, with a distance between centers of twenty-two inches, to have another pair with a ratio of seven to one, the spur having a pitch-diameter of thirty-eight and one-half inches to the pinion's five and one-half inches. The four and one-half to one gears being removed, the seven to one can be keyed on in their place. These gears should have wider faces than those which do less work, as the strain on the teeth is greater.

Another way is to fasten to the end of the boom a ring or a stud to which the hook of the hoisting-rope or chain may be attached after the rope or chain is passed through a single block having a hook to which the load may be made fast. The result of this will be that for every foot of chain that is hauled in by the windlass the load will be raised only six inches, so that the hoisting-power of the crab will be about doubled. (It would be just doubled if it were not for the friction of the extra block.)

Of course, neither of these methods will enable a crane to raise a weight greater than can be properly put on its frame or on the chain and gears. If there should be any doubt about the latter, the windlass may be made to do double work without putting any extra strain on the frame which bears it, or on the chain itself, by catching hold of one end of the load and raising it, using the other end as a fulcrum; raising as high as is convenient, blocking up at the raised end, catching hold of the other end and doing the same thing, and so on, alternately raising, blocking and shifting. This plan will answer better for long articles such as very heavy girders or posts, or for long cylindrical boilers, than for short ones like marine engines.

This plan of increasing the hoisting-power of the crane is sometimes desirable, not because the crane itself or its chain or gears may be weak, but because of lack of good hoisting-power. In some parts of the country, or in some conditions of the labor market, there may be insufficient man-power at the crane; but if the gear may be changed from four and one-half to one up to seven to one, one strong man can do as much work with it as two light ones; or two light men can do as much as two strong ones.

Where there is no crane that may be made of sufficient power, or where the existing cranes will not reach, there should be some one about the place who has ingenuity enough to rig up a tackle out of a few ropes or chains and blocks, attached to the overhead timbers of the building, if there are any available, and if there are not, by the use of spars or of long balks resting on the wall-plates or in the upper window-opening, or set in a tripod on the ground. Such spars should be lashed together with a rigger's hitch or with some of the suitable rope-fastenings which may be learned from Brainard's little book on "Knots, Splices, Hitches, Bends and Lashings." Care should be taken to have the spread of the timbers as great as possible in order to give sufficient room among them to manœuver the piece to be lifted; although it must also be remembered that the more spread such tripod has for a given length of legs, the less load it can carry; a fact that must be borne in mind in handling heavy weights with long light timbers, the strength of which has never been proved. All such timbers, if not perfectly square in cross section, should be so placed that the strain will come on them in the direction of their greatest width. Thus a two by eight is sixteen times as strong edgewise as crosswise, to a load applied at right angles to its length; and while this same ratio does not apply to where it is used as the legs of a tripod, and gets strain partly endwise and partly crosswise, this fact should be borne in mind and taken advantage of.

All hoisting-chains should be annealed from time to time. After they break and kill someone is the wrong time to anneal them; prevention is better.

The bearings of all blocks should be kept well lubricated with black-lead, either with or without tallow or other grease. Those which have hinged shells are better than those with solid blocks, because they will permit the rapid reeving through them of ropes or of chains having hooks on their ends; it being easier to open a snap-block, lay the rope or chain in the groove, and close and latch the shell, than to unbend the rope from the hook or detach the chain from it—especially in view of the swivel that there should be at the hook.

Hoisting-rope should be chosen not only with reference to its strength and durability, but with a view to flexibility. It will be found well to smear all hoisting-rope well with graphite (black-lead) and with a trifle of tallow. This will greatly increase the ease with which it reeves through the blocks, and to some extent lessen its stiffness without impairing its strength.

All hoisting-ropes and chains should be kept, when not in use, either extended in place all ready to be put into service on a moment's notice, or properly coiled up in parallel "fakes" of easy curve; then they will last longer and be more readily paid out or handled when the time comes that they are wanted.

How to Handle Large Castings. Balance is the thing. Here you are straining everything and every-

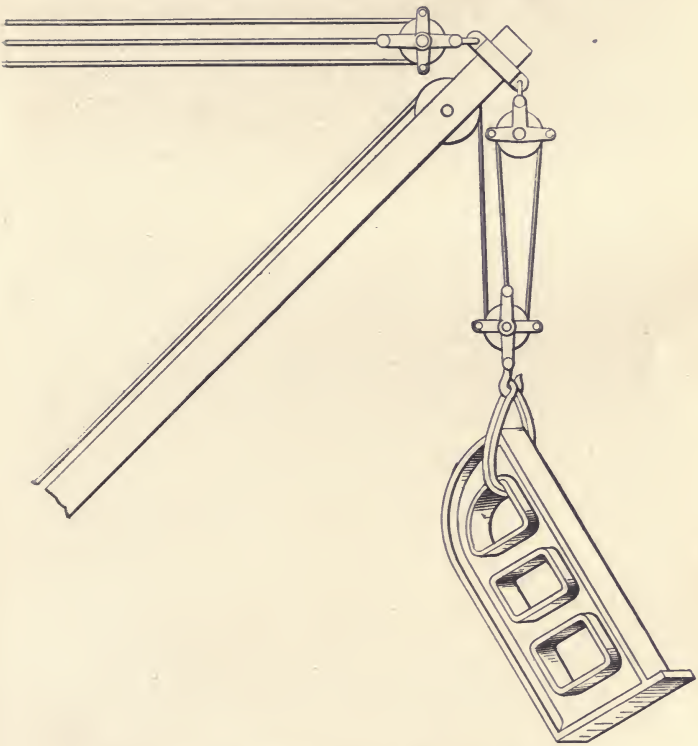


FIG. 178.—HANDLING LARGE CASTINGS WRONGLY.

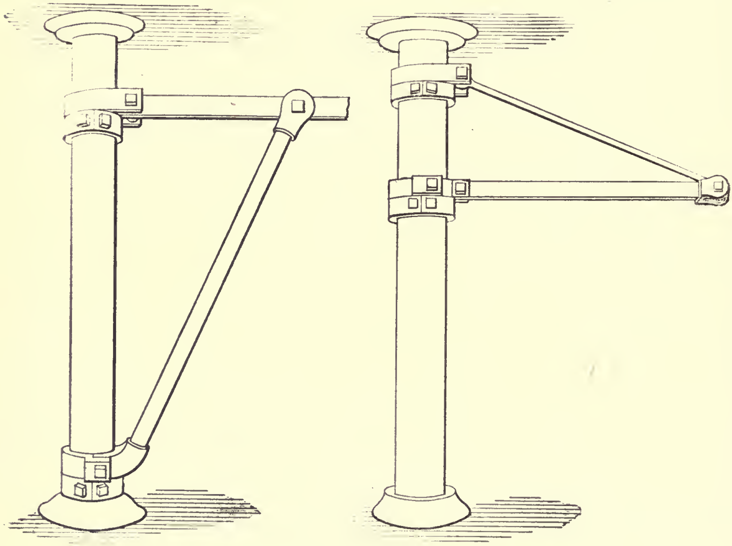
body, because nearly every one that you have slung is so hung that it will only hang one way, and in addition to that it hangs lower than it should to be conveniently handled, requiring you to lift it higher than if you were to sling it differently. Now in raising Cleopatra's Needle, which is somewhat of a massive stone, the engineers calculated its center of gravity so nicely, that when they got on its iron jacket and raised it by its trunnions, it balanced so exactly that one man could cause the entire great mass of two-hundred tons to swing. Don't you suppose that that enabled them to handle it more easily than if it had been picked up about five feet to one side of its center of gravity, so as to have a long end tipping down and leaning against everything in the way?

Electric Cranes. Now-a-days instead of getting in cranes where they will go, the shop is designed to fit around the crane; and in two cases out of three it will be an electric crane. Down the center of the modern shop is an immense nave like that of a church, flanked on either side by two-story or three-story galleries, above what would correspond to the transepts of the church. The great master-crane travels the full length of the shop and handles every heavy piece; its movements being governed by from one to three motors and comprising hoisting, lengthwise motion, and traversing, each at variable speeds suitable to the work to be done. In the Baldwin Locomotive Works, one of the new shops has track accommodations for seventy-five engines at once. Every place in it is controlled by the great traveling crane, which has a capacity of one hundred tons and will pick up the heaviest engine built, lift it high above all the other work in the shop, and carry it to any place selected; and when all the operations are completed will place it on the two main cross-tracks, on which it may be taken out of the shop with its own steam—or, as is more usual, towed out. In another shop, in handling locomotive-drivers on their axles—formerly such a pair of wheels took about thirty men half an hour to get them from where they were finished to their place at engine for which they were designed; now, with the electric crane, two men do it in five minutes.

The question of three motors *versus* one is often agitated. The Baldwin people prefer to have all three of the movements controlled by but one, and to have another as a spare, all ready to be thrown into service in ten minutes in case of break-down of the regular one. Where there are three, they claim that there is three times the chance of a break-down; and a break-down of any one of three puts the entire crane out of service.

A Wrinkle About Cranes. There are, of course, thousands of shops where it is not possible to put in electric cranes, and where it would not be advisable to go to the expense even if it were possible. Yet there arise emergencies when it would be desirable to have a crane in some particular place, just for a day if not permanently.

Noting in the cylinder-shop of the Baldwin Locomotive Works that on every other post there was an electric jib crane which commanded practically the entire space in a radius up to the next post, so that the heaviest cylinders with their saddles and all could be taken right out of one special tool and landed in another on a truck, the idea occurred to me that in shops similarly constructed, having circular iron columns supporting the roofs or holding up galleries, it would be feasible to have collars bolted around every post, near the base and above, and to have jib or other cranes which might be temporarily affixed to the post; being operated by hand or by electric motor as might be desirable. A shoe partly embracing the pillar at the bottom and resting on the collar, would serve as the lower support for an iron tube for the jib proper, and would receive thrust strains only; a strip encircling the pillar near the



FIGS. 179 AND 180.—TEMPORARY CRANES.

top would answer as the point of attachment for a narrow beam of rectangular section, bearing at its outer end on the outer and upper end of the boom; and on this would play the pulley-trolley. Where the pillar was large, there could be two tubes for the boom, these coming together at the top in *A* style.

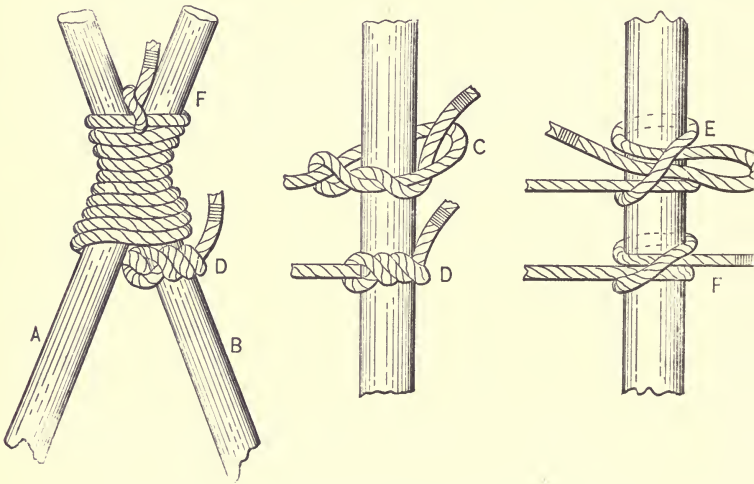
Such a temporary crane could be put up in a short time by two men, and would serve to handle pieces cheaply, which would otherwise cost a great deal of labor and consume a good deal of time to move.

A good swabbing with black-lead (graphite) and tallow on the top edge of each collar would make the device slew readily. The lower shoe would require a back-strap to prevent accidents, but this need not be heavy. The upper member having a pull on it should encircle the pillar more completely.

A variation of this for such places as would not permit very well of the space about the bottom of the pillar being taken up by a crane, would be to have two collars both well up on the hight of the pillar; the lower one to receive a shoe for the support of a horizontal beam of rectangular cross section, and the upper one to take the downward thrust of a strap, having attached to it one or more tension members supporting the outer end of the jib. (See Figure 180.) In fact, the same pillar might have all three collars so that either portable crane could be affixed to it as occasion warranted.

Lashing Derrick Timbers. With ordinary temporary derricks, consisting of two timbers lashed together, there are many wrong ways and but few right ones of lashing so as to be sure of three things: (1) that the lashings will hold, (2) that the timbers will neither spread further nor come together when the strain is on the lashings, and (3) that the lashings can be got apart when the work is over and it is time to take down the derrick. Before doing anything of this kind it will be well to remember that of the two usual ways of lashing, there is one which has a tendency to "gather" the legs together when the strain is put on it, and another which has a tendency to spread them farther apart under the load. This tendency may in either case be counteracted during the lashing and erection so that it may be made an advantage instead of a disadvantage.

Figure 181 shows two round timbers, *A* and *B*, which are lashed together so that there is a tendency to bring the "legs" closer. To make this lashing,



FIGS. 181, 182 AND 183.—LASHING DERRICK TIMBERS.

fasten one end of the rope to the end of timber *A* with a "timber hitch," (shown in Figure 182 and explained later) then pass it around the horizontal crotch of the spars from back to front and left to right several times, bring it through from the back to the front and secure it to the last cross-turn with a "clove hitch." (Shown in Figure 183.)

While making this lashing while the timbers are on the ground, the feet should be brought closer together than it is desired that they shall be when erected and in use; then when raised they should be spread apart, which will tighten the lashing.

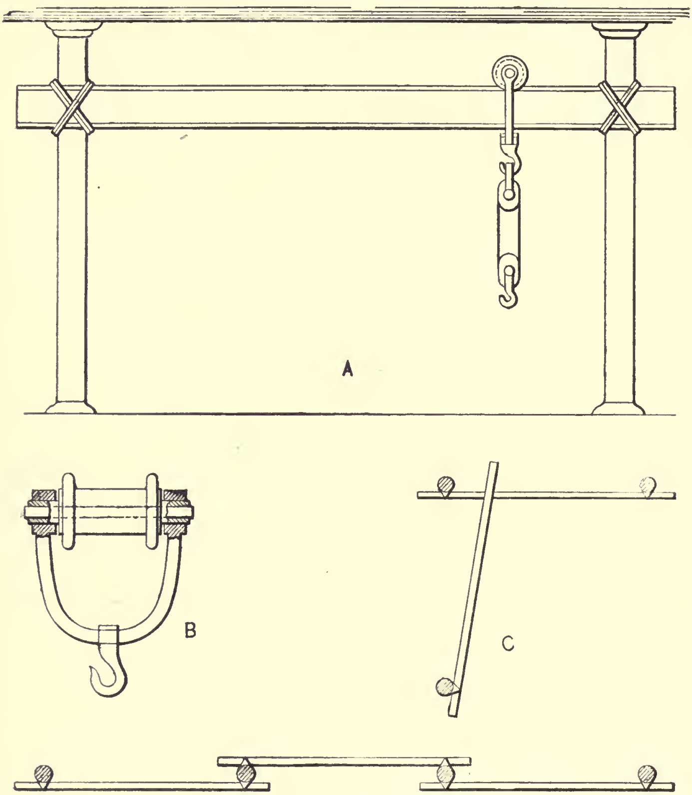
To make the "timber hitch" for the purpose of holding the free end of the lashing in beginning, take the free end around the timber, then back around the standing part, then give it a few turns about itself, and haul taut. (See Figure 182.)

The "clove hitch" is made either as at *E*, or as at *F*, Figure 183. When made as shown in *E*, it may be cast loose at once by hauling on the free end; as *F* is rather more difficult to unfasten.

The "straight-spread" lashing is made in the same way as the straight gathering kind shown in Figure 181, except that the rope is passed through the vertical crotch instead of through the horizontal. In making it the two legs should be spread farther apart than they are desired to be when erected; and then bringing them together when they are lashed, the lashing will be tightened.

Serve the free end of the rope with small cord to keep it from unraveling.

Temporary Hoisting. Once in a while it becomes necessary in almost any shop to carry an extraordinarily heavy piece to or from some quarter that is not served by the cranes. It is of advantage to be able to do this even if the floor is cluttered up with other pieces which are not ready to be moved. Very often a heavy casting is moved out of the way to make room for another one along the aisles between the machine-tools. Sometimes it is necessary to instal a new machine in the place of an old one while the floor is pretty well covered with work or machines; and then it is, whether the shop has railways down



FIGS. 184, 185 AND 186.—TEMPORARY HOISTING-DEVICE.

the aisles or not, when it is desirable to be able to handle the heavy pieces from above instead of along the floor level. This is often the case in shops where there is a big central traveling crane serving a long "nave" bounded by galleries on each side, which it cannot reach and is not ordinarily supposed to reach, even through railways or by trucks.

It would seem a simple matter to rig up a temporary overhead single railway, but very often tools are moved to right or left, and work not yet ready to remove is taken away in order to permit the pieces to be handled on the floor level.

Figures 184, 185, 186, show a rig that takes few men to put up and take down, and by means of which quite heavy castings, forgings, or other pieces, may be lifted clear above everything on the floor and got out of the way. We assume that the shop has posts or columns supporting its roof or a story above, and that an iron I-beam is available. In this case all that is necessary is to lash the beam to the columns as shown, and having straddled it with a flanged wheel of spool shape, sling from this last the hoisting-apparatus, whether it be a regular differential gear or an ordinary double block and tackle. The load may be lifted clear and run along as far as the end of the rail on the next post, and if it is necessary to run it at right angles, it may then be shifted to a similar tackle on a similar beam placed across the first, and its other end either resting on a parallel beam or lashed at and to another post; forming in this case an obtuse angle with the first beam.

This spool or flanged wheel may have, in order to save friction, a plain length of shafting of small diameter passing through it and bearing on each end a sleeve of iron tubing, bored inside to fit it and turned outside to receive eyes from which depend the upper block of the tackle.

If there is any question about the strength of the lashings, they may be supplemented by plain shores of ordinary timbers, and placed vertically or nearly so, alongside of the columns.

With two sets of tackle-blocks a load may be transferred from almost any column in the shop to almost any other; one hoist taking it from the other. Thus in one figure it is carried in one straight line along a row of columns while in another it is switched off to a line of columns at right angles with that along which it first started.

As to Hoisting-Ropes. So you have broken that hoisting-rope. Well, the only wonder is that it did not break sooner. You use too small sheaves. Every rope has some stiffness; any rope of large diameter drawn over a pulley of small diameter must stretch along its outer edge (if the word edge may be used) and be compressed along its inside edge; and there must be friction between the core and the inside and outside fibres. The chafing between the rope and the sheave is only a part of the friction that goes to wear out the rope. If the internal strands or core were black-leaded, the casing-fibres would slip on them and there would be less of the internal cutting. The original strength of the rope would not be increased, in fact might be slightly diminished by the plumbago overcoming the friction which alone holds the particles of the rope together in spinning; but the general result would be desirable. Such rope is used with success in large coal-hoisting and conveying plants.

Annealing Crane-Chains. Don't wait for one of your crane-chains to break while there is a heavy load on, and let a piece of work drop and be ruined, or kill or maim some one. The first thing that you do with a chain should be to anneal it, unless you are definitely certain that it has been annealed by the maker. Then from time to time anneal it again. Just heat it hot, and let it cool slowly; that is all there is to do.

Fastening Hoisting-Ropes to Hooks. Being in a shop not long ago when a load fell by reason of being improperly secured to the hook, I have thought that it might be well to show the proper way of making fast in such a manner as to get not only speed in

FIG. 187.—BLACKWALL HITCH.

making fast and in letting go, but absolute security as far as slip of the rope is concerned.

Any "sailor man" will tell you that the proper way of making fast in such case is by a "Blackwall hitch." This is made by laying the end of the rope across the hollow part of the hook, (say from right to left) then taking the "standing part" (that is, *not* the free end) back over the neck of the hook (say from left to right) and bringing it down in the hollow of the hook (say from right to left) over the "free" part or end.

In making this hitch, the loop is *not* to be brought down into the hollow of the hook, but kept well up on the neck as, shown in Figure 187.

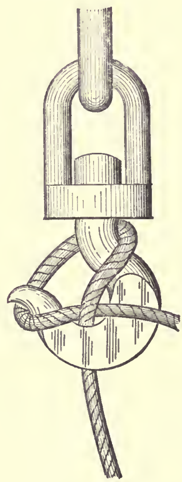


FIG. 188.—BILL HITCH.

While at it, I may as well say that the best form of hook with which I am acquainted is that shown here, which is of a kind that does not open out readily under strain, as so many hooks do; nor is it apt to break in the curve when a load is suddenly brought upon it, as may be the case when using chain, by reason of a link getting suddenly unkinked. This is the form laid down by the Yale & Towne Co.

To make a "bill hitch," which may be considered as slightly more secure than the "Blackwall," proceed just as for the "Blackwall" passing the free end of the rope along one side of the hook (say to the left) then around back of the neck (say from right to left) then bring it in front of the "bill" (as from left to right) and pass it under, between rope and hook; all as shown in Figure 188. Or go about it the other way to; pass the free end under the standing part, from left to right, making a loop with the ends to the right; slip this over the bill and the neck of the hook, (beyond the bill) so as to let the standing part pass into the throat to the left, and the free end lie to the right.

Splicing Wire Rope for an Eye. Where you want

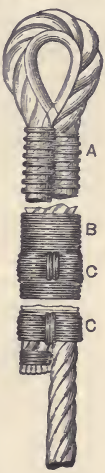


FIG. 189.—SPLICING EYES INTO WIRE ROPES.

to splice an ordinary wire rope for an eye, so that it will be as strong in the splice as in any other part, it will be well to follow Admiral Luce's directions, using a stout thimble in the eye and carrying the end of the rope back about twelve feet along the main part. The two parts of the rope are then lashed together, first with what are called "racking lashings" *A*, which alternately pass over and under the parts, forming a sort of figure 8. After you have done this for the whole length of which the end has been turned up, put on several short lashings *CC*. The upper part of the illustration, Figure 189, shows how the racking lashings are put on. When they have been put on the full length, the lashings *B* are carried straight around for the whole distance.

Securing Brick Veneers. Several methods have been proposed and used for securing brick veneers to

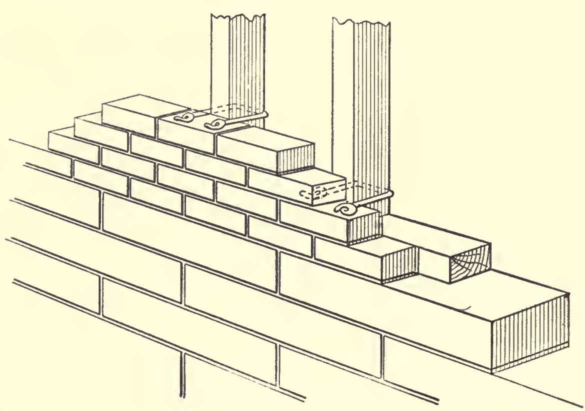


FIG. 190.—SECURING BRICK VENEERS.

the frame; some of them are expensive, some inefficient, some unsightly, and some, two or even all of these. Here is one that I am using on my new office front. The binders or hold-fasts are lengths of stout galvanized iron or steel telegraph-wire (plenty of which is lying about the street or to be had for a mere song or even for the asking) a little longer than twice the width of the uprights plus one width of the brick. These pieces are bent into U form, using a piece of the upright stuff as a former and seeing that the bends are square and snug. The free ends are slightly twisted, and hammered flat in the plane of the U. They are used as shown in Figure 190, passing about the uprights and lying between the courses of the brick-work.

It may be added as a sort of after-thought, that in picking up wire from the street it is well to see that both ends are in sight, as, in these days of electricity, many an inoffensive-looking wire proves to be "live."

Pattern-Room Ceiling. In an article descriptive of the shops of a certain railway company in New York State I read in connection with the pattern-room "the inside of this room is ceiled with waste matched pine and varnished, giving it a very neat and clean appearance, besides making it a very warm place in winter."

Before putting a varnished pine ceiling in your pattern-shop, or your office either for that matter, ask your insurance man about it. Next get the opinion of the chief of the fire department. Then maybe you will select some other kind of a ceiling. Perhaps you have been to a few fires yourself and know how warm one of these ceilings can get either in summer or in winter, if the conditions are favorable.

For my part I would rather have the joists show and be kalsomined to give light in the room, than to coat them over with a fire-trap sheathing of varnished pine which would diminish the hight of the room.

Floor-Timbers in High Buildings. I saw a nice wreck not long ago; a city machine-shop that had been through a fire—or rather the fire had been through it. The whole shop was in the cellar. It had seemed a stiff enough floor, but there lacked one precaution that is very seldom taken with high buildings: so supporting the timbers of the floor that, in case they break or fall, they shall not pry the wall over inward, and that in case they expand they will not push it over outward. As ordinarily constructed, and as was the case here, holes are left in the walls, into which the ends of the joists set ; the holes being about the size of the ends of the joists, so that in case the floor falls the timbers are apt to tumble the wall inward on the contents of the building.

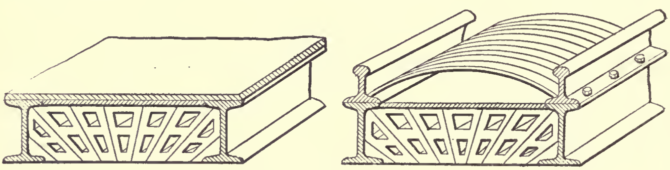
There are two ways of getting around this. One is to set the end of the joist upon a corbel or projection from the face of the wall, so that the joist clears the face of the wall entirely, and in case it falls it exerts no influence upon the wall. The other method has the same object in view, and accomplishes it in a simpler way. The holes made to receive the joists are made about twice as high as the joists, so that in falling the joist has no prying effect upon the wall. These remarks apply to iron as well as wooden beams ; but for iron beams there should be observed the additional precaution to leave a greater space between the end of the beam and the wall, so that the inevitable expansion of the beam from fire shall cause no thrust outwards, tending to overthrow the walls. It would perhaps be as well if all external walls were held together by anchor bolts with external plates, which, although not very sightly, yet often tend to hold the wall up when otherwise it would topple and fall outwards. Of course, if the beams are properly cased below with some fire-proof material or by some heat-proof method, their expansion will be very much less than if they are left naked to the action of the heat.

Floors and Joists. I see that my neighbor's new shop floor has a "bagged" appearance already. Few floors are stout enough and stiff enough to remain level more than a few months at most after being laid. They will sag between supports, so that even a sixteen-foot room which will permit of a marble being laid near the washboard without its rolling toward the center is a rarity. The sag in most ordinary dwelling-houses soon amounts to one-fourth inch, and often reaches one-half inch. Putting the beams close together, or using thicker beams, does not seem to improve the matter much, and deepening them is rarely admissible, because people want all the headroom that they can get, and begrudge every inch of joist-depth. Besides this, increasing either the number or the thickness or the depth of joists costs money. But there is a way by which a level floor may be had without greatly increasing the timber bill, and that is by cambering all the joists from one-fourth to one-half inch, and starting with a floor rather higher in the middle than at the two sides at which the joists end. An upward camber of one-half inch in sixteen feet of a ten-inch joist, the eamber being measured with the joist lying on its side, will become only about one-fourth inch when the joist is in place, without the flooring being laid. The weight of the latter will at once sag it until it is very nearly level, leaving for time and the weight of the furniture to relieve, not any more than—perhaps not so much as

—the sag which would have been in the new floor if the joists had been sawed straight.

"Strengthening" Floors. One of the very best ways to learn how to do things right is to note how they have been done wrong. Notes of bad practice are danger-posts which tend to keep us in the middle of the road and not let us stray into the marshes and pitfalls on either side.

One of the most marked examples of how not to do it may be seen (no, it may not be seen, it is covered up) in one of the largest, finest and most imposing and expensive hotels in New York City. It was found or thought, after about $1,000,000 had been



FIGS. 191 AND 192.—"STRENGTHENING" FLOORS.

spent on the structure, that the floors were too weak; and of course they had to be strengthened before the building could be finished or used. As at first constructed, they were of the ordinary type, made of I-beams having flat composition arches sprung in between them.

The conditions were such that the floors could not be ripped out; but of course they could be strengthened by any one of several different methods. They might be trussed from below, or shored up by more columns; or some of them might be held up by suspension rods from above. But none of these ways seemed to suit the architect. The highly original plan which he adopted is shown in Figure 192, in which it will be seen that he simply laid down on each I-beam an inverted deck-beam, which he bolted fast to the I-beam by its flanges; then he sprung an arch of corrugated iron between each pair of these deck-beams, and leveled the whole thing off with concrete, on which the floor-boards, or the tiling, as the case might be, were laid.

This method of strengthening arches beats all hollow the scheme of lightening the load on the horse that was carrying a man in the saddle and a small boy on the crupper, by the man taking the small boy in his arms.

A Good Shop Floor. About as good a shop floor or yard pavement as you can put in for such a place is made of cedar blocks say six inches long, and of the diameter of the tree—four to eight inches. Ram down some ashes so that they will be level, then put your cedar blocks on them, close together, and fill up between them with a grouting of asphalt and gravel or asphalt and sharp sand. Wagon-wheels won't "phaze" such a floor or pavement.

You may also make a good shop floor by tamping down first gravel and then sand, and rolling well with a heavy roller; next laying down inch boards that have both sides coated with heavy tar, and then other boards crosswise of these.

Light Floors. That printing-press runs hard because the floor is too light, and after the owner had got this press running all right he put alongside of it another one which sprung the floor and twisted this one. You will have to level it up; although the probabilities are that after you have done so, the first time he puts down a big stack of paper alongside of the new press, the floor will sag again. The best way is to shore up the floor from below, or if that is not convenient, to run a big beam across above there, and hang the middle of the floor to it by a stout iron rod with a big washer and two good bridge-nuts at each end.

A New Wrinkle in Car-Shops is to dig a long pit and lay in it a track to hold three or four cars, their floors coming about the level of the shop floor.

Shop-Lighting. There is a "dim religious light" over in the north-west corner of your shop, and it seems to me that it takes the men about seven times as long to make an adjustment or to read a measurement as in the corner diagonally opposite. Your pattern-shop wall comes close to the window in the dark corner, and you have outside a wire screen, that was put on years ago before the pattern-shop was built, to keep boys from breaking the windows. Inside that wire screen there is a coating of grime and dirt that is just as old as the pattern-shop—about five years, if I remember rightly. If you will take down the screen (which is of no use), that will give you a trifle more light and give you a chance to send a man outside with a hose and a brush and wash down the windows, and then if you will send another out with a bucket of whitewash, a wide brush, and suitable instructions to brighten up both the walls that face each other in that manner, you will have light reflected into the shop, and the men will be able to see whether a thing is eleven-thirty-seconds or three-eighths. In this country, at least, sunlight costs practically nothing; why not use it and plenty of it, particularly when your men want it and are losing time for lack of it? If there comes in too much for their eyesight they can put up a temporary sheet of brown paper; but I guess that in that particular geographical corner, and as long as the pattern-shop stands there, there will not be any blinking, especially of afternoons.

Shop Windows. It would seem that a window 6 by $3\frac{1}{2}$ feet would give about the same amount of light through, back of it, whether it was high up or low down; but such is not the case. By a well-known law of optics, "the angle of incidence is equal to the angle of reflection," so that light which strikes on the ceiling from a low-down window reaches the floor near the wall in which the window is placed; while a window of the same size, higher up, will allow the rays to reach farther back on the floor. This is but a trifle, but as Michael Angelo said, "trifles make perfection."

Where to Put Shop Lights. There are shops where the men cannot do so much work with arc lights hung up far above them as they could with an ordinary oil lamp or stub-end of a candle. The reason is that the arc light does two things—it casts dark shadows, and it blinds the eyes of the men by being too concentrated. It is much better to get the same amount of light nearer the work, even at the much greater cost per candle-power of the incandescent light. I say "per candle-power," for while a 1,000-candle-power arc light may not cost more than one-half to one-third horse-power to maintain, 1,000 candle-power of incandescent light (say sixty 16-candle lamps) cannot be got for less than six-horse-power, and usually takes nine. But the fact of having such light right down at the work enables better work to be done where the same light is given, or enables much less candle-power to suffice; for it is a well-known rule of lighting that one candle-power one foot from the work is equal to four at a distance of two feet, sixteen at a distance of four feet, and so on.

Cool Water for Shops. The temperature of the earth below the top ten or twelve feet seldom varies very much, particularly where the surface is covered with a building, so as to prevent the sun heating and the winds cooling it. Taking advantage of this fact, one may at no very great expense make the drinking-water of any shop much cooler in summer than it is apt to be without such measures being taken. A trench is dug as narrow as possible, and as deep as may be convenient, running the entire length of the cellar. In this there is laid an iron pipe "coil," as a zigzag or alternate run is generally called, the pipe being at least double the capacity of the service-line of the house. Upright lines are run from this above-ground for connection with the street mains and with the service-pipes, and the trench then filled in. When the connections are made, the water from the street (warmed as it generally is by exposure to the sun's rays in a shallow reservoir, and often not improved by its passage through shallow-laid mains) has to make several turns through the earth-cooled coil before it reaches the service-pipe. The same effect may be produced, where well-digging or boring apparatus are at hand, by sinking a vertical cooling-pipe of several turns in a well of small diameter, and then filling in the well.

Shapley and his Shaft. Shapley had a leading-shaft that he had been trying for about ten years to convince himself was heavy enough for the power which he had been putting through it; and after all these years of wabbling about from one side of the question to the other, he came to the conclusion that it must go. So he ripped out the three-inch shaft and put in a four. It cost him considerable money and took a good deal of time; and of course the earnings of the shop during that time very much lessened. And after all that, fancy his feelings when one of his sons came back from college and said to him: "Why, pop, that's rather a fool job that you have been paying for! Why didn't you just turn the old line around a little faster and alter the pulleys at each end? You don't take any power off the line between the ends, and as it is, both the old shaft and the new one have been speeded too slow for the machinery at the end furthest from the engine."

Shapley feels something like the man who had been winding up a clock every day for twenty years and then found out that it was a twenty-eight-day clock. But perhaps there are more Shapleys in this great country of ours.

Jack-Shaft Stands. Some people seem to think that any kind of a floor-stand is good enough for a jack-shaft; whereas it should get all that is rigid, adjustable, self-oiling and convenient. The jack-shaft gets hard work and plenty of it, usually heavy belting and high speeds, and gets more work than any other part of the system, first because all the power goes through it; and second, because it is always in motion so long as there is anything to be turned. The stand should be rigid both laterally and fore-and-aft; it should have an adjustable pillow-block with self-oiling bearings and both lateral and vertical adjustment. With such stands there need be no trouble if the bearings are of proper dimensions and material and the lubrication is suitable.

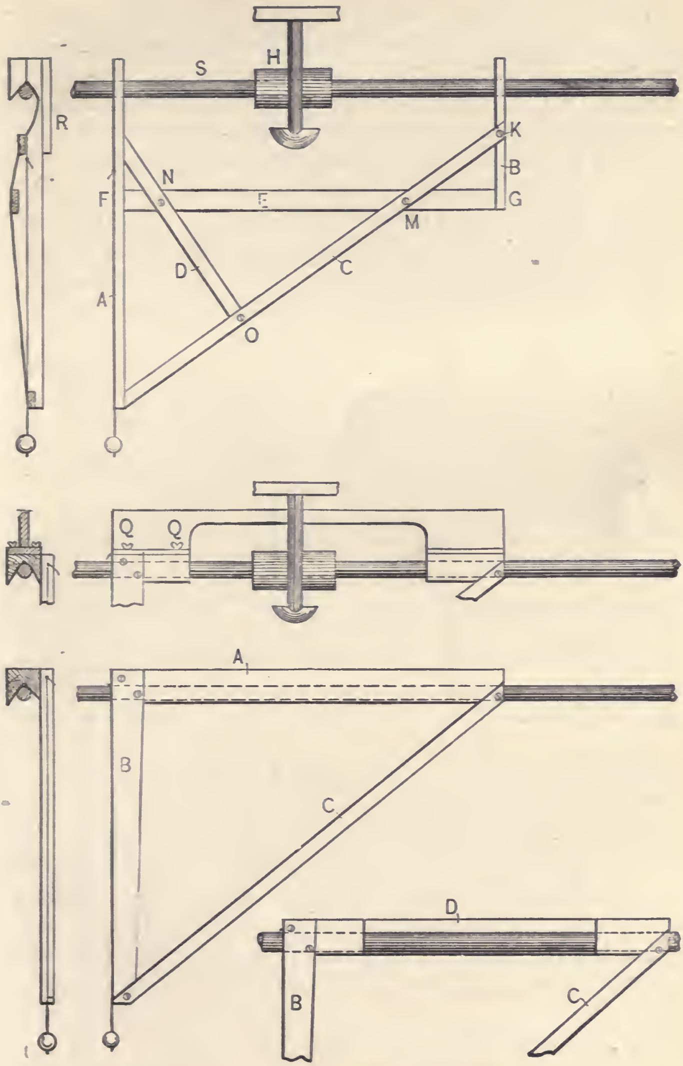
Lining up Shafting. In lining up shafting the problem is to get the line not only straight but level. A line may as a general thing be straight, without being level: that is, a center-line drawn through the whole system might pass through the exact center of every section and yet one end might be higher than the other. It might be level without being straight; thus each section might have kinks in it, or the whole line might be bowed in a horizontal plane; yet it might all show up perfectly level by any system tried.

There are two ways by which the level of a line may be found; and if not level, by which it may be made so. One is by the water or spirit-level, and the other by the plumb-line.

Whatever method be employed it must be available for every kind of a line that one is liable to find; that is, those which have great distances between hangers, and those which are very much interrupted by them.

At present I shall show a few ways by which the plumb-bob is used. We shall have to assume that we believe or rather know certainly that a level line or plane is at right angles to a vertical line or plane; and that a plumb-line is a certain method by which to ascertain the verticality of anything already erected, or by which to erect or adjust anything absolutely vertical.

Referring to Figure 193, in which *S* is a line of shafting presumed to be already erected as nearly level as the eye can tell, and *H* one of the hangers, we have here a device by which the line on both sides of the hangers may be leveled at once; and of course, the same appliance may be and should be set up between



FIGS. 193 TO 196.—LINING UP SHAFTING.

hangers. *A* and *B* are two pieces of board each of which has a lengthwise center-line scribed thereon; and has also portions cut away so as to leave notched pieces, truly centered, and both alike, by which these may be hung from the shaft. These notches are made correct by the two pieces being screwed together and of a truly-centered hole with a diameter within two inches of the width of the boards made through both at once. Then tangents are drawn to the sides of the hole, at equal angles with the center-line, and the stuff is cut away so as to present the appearance shown in the end view Figure 193. The longer *A* is, the better; *B* may be about two feet. Brace-pieces *C*, *D* and *E* are then made, and *E* is first attached so as to be as nearly as possible square with both *A* and *B*, which two should then be parallel. One screw is at each of the joints *F* and *G*. Then *C* is attached to *B* by one screw at *K*; then it is attached to *A* at *B* by one screw, after *A* and *B* have been brought absolutely square with *E*. This being done, one screw is put at each of the places *M*, *N* and *O*; a distance-piece as thick as brace *E* being required at *M*. When the frame is thus pinned together, it should be absolutely rigid, and the squareness of the working-edge of *A* (that shown to the left) with the upper or working-edge of *E* should be well tested. This being done, if the system is hung on the shaft as shown in Figure 193, a plumb-line suspended along the working-edge of *A* will show this edge to be absolutely vertical if the shaft is absolutely level. It is well to check the accuracy of this, (1) by sliding the device along the shaft from one end to the other, skipping the hangers and couplings when they are encountered, and then (2) running it along the line in the same way, the other way to; that is, with the working-edge towards the other end of the shaft.

To make the plumb-bob come to rest more quickly than it otherwise would, it may be allowed to hang in a bucket of water. *A* may be strengthened where cut away, by a reinforcing-strip *R*.

A variation of this device is shown in Figure 195, in which *A* is a piece of four-by-four-inch scantling, along which a lengthwise center-line has been scribed, top and bottom, and in which an angular groove has been cut, truly parallel with these center-lines. This work may be done on an ordinary patternmaker's saw-bench. Then a piece *B* with one perfectly straight working-edge is screwed to *A* absolutely at right angles to the top and bottom edges of *A*. A brace-piece *C* extends from *A* to *B*; and the plumb-line is hung along the working-edge of *B* as shown in Figure 195.

Instead of having long heavy pieces of scantling, say six feet long, as shown in Figure 195, a two-foot piece may be scribed, grooved and then sawed across in two, and the two pieces joined in true parallel by a lengthwise piece *D*; then the piece *B* is made square with the joined grooved pieces and the brace *C* put in to keep them stiff. If necessary, another brace *E* may be screwed between *A* and *C*. (See Figure 196.)

All three of these devices may be unscrewed so as to make them take up less room in storage; but before doing this, all the parts should be marked, and the screws should be coated with a mixture of graphite and tallow and tied up in a paper that is fastened to one of the pieces. Then all the pieces should be fastened together.

Any one of these three rigs may be used with a level to check the accuracy of the plumb-line, if desired.

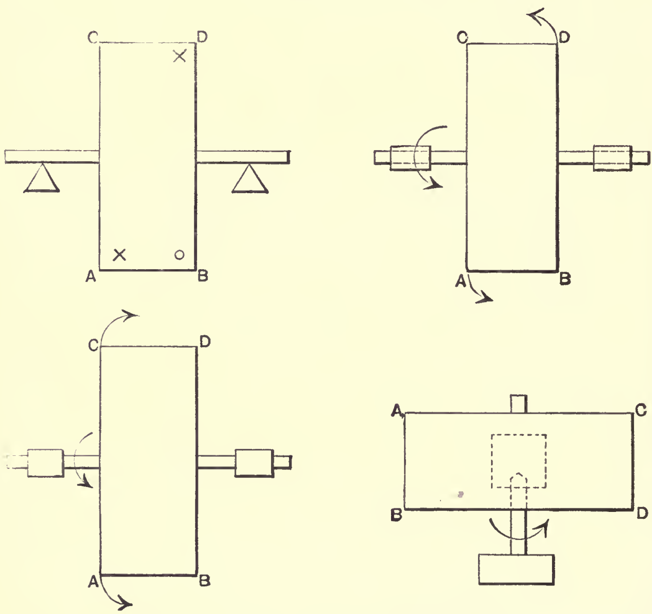
The second and third styles cannot straddle hangers very well; but the third one can be made to do so by a slight modification as shown in Figure 194; and where a hanger is of an especially difficult pattern to "get true" the connecting-piece may be attached to one of the grooved pieces by thumb-screws at *Q Q*.

Barbarous Shaft-Couplings. They had a sad accident over the way, and one that might just as well have been here, for all the precautions you have taken to prevent the very same thing happening. A man was fixing a belt-shifter; his sleeve caught in a flange coupling, and his arm was torn out of its socket before help could get to him. He will die, of course. Every one of those nuts which sticks out from a plate coupling invites accident. I don't see why people will hold on to such barbarisms. Considered as couplings they are not a success. They are big, heavy and expensive, take time to put up and time to take down; and half the time when you try to take them down you find that they have rusted together. If a belt gets thrown off a pulley, and its edge strikes one of them, it is ruined. If it is a rubber belt, that is the end of it; you can't even cut it down and make a narrower one out of it. And in case of some poor devil's sleeve—or what is worse, some poor girl's hair—getting caught, there is a horrible accident which no mere money can measure, for which no mere money can pay. If people will put up such abominations, they should be compelled to case them in, or to have them so constructed that there are no projecting parts like bolt-ends. Any one who has ever used a compression-coupling knows how much more handy it is than the other—that is, if you get the kind that can be taken down as readily as it is put up. Some of them are easy to screw up and difficult to take off; they are like lobsters, that are said not to let go until it thunders or until the sun goes down.

Pulley-Balancing. If some one were to put a heavy eccentric on one of your shafts and let it hang with one big side and one little one, you would not like the effect that it produced; you would complain that the motion was wearing on one side of the shaft, and that it made the machinery run unevenly. But while you may not have anything that really sticks out farther on one side than the other, in the way of an eccentric, you have on your shaft there a pulley that is jarring things and wearing the journals on one side—a big pulley that is very much out of balance. I suppose that somebody, when he put up that pulley, or before he put it up, gave it what is mis-called "standing balance"; which is about the kind of a balance that the tight-rope walker has when he is lying in bed sleeping—a very safe balance under the circumstances, but not worth a continental for purposes of tight-rope walking. Standing balance is of no more use to a running pulley than a life-preserver in some one's store on Broadway would be to a man who fell overboard in mid-ocean.

But if I had a dollar for every pulley running in this country—or even in the city of New York—on standing balance only, I would be rich enough to make some very decent Christmas presents. What a pulley wants—or rather needs—is *running* balance. It should be tested when it is running, in the position in which it is run, and at the speed at which it is to run. Then if it has any eccentricities of size or weight they will develop and may be corrected before it is put to work shaking buildings.

Some so-called mechanics think that, when they have run a mandrel through a pulley and let it roll



FIGS. 197 TO 200.—PULLEY-BALANCING.

about a bit on two straight-edges placed on trestles, they have got a perfect balance when they have reached that condition, by adding weights or boring holes, in which the pulley will lie indifferently with any side up. As a matter of fact, such balancing may make things worse than before, when the pulley is running (and most pulleys are meant to be used running).

We will suppose a pulley such as that shown in Figure 197, where there is an excess of weight at *A*, over in one edge. Of course when put on the straight-edges it tends to hang with the *A* side down.

Any fool knows that the *AB* side, taken as a whole, is heavier than the *CD* side, directly opposite. And any fool knows that if weight enough was added anywhere along the *CD* side, or if weight was taken from the *AB* side, the pulley would stand with *AB* up as well as with *AB* down. Well, we will suppose that we add weight enough at *D*, diagonally across from *A*, to make the pulley stand with *AB* up just as willingly as with *AB* down. Now put that pulley on a shaft and run it fast. The tendency of the weight at *A* is to fly tangentially from the pulley, and so long as it can not fly off so, to cause a radial strain in a direction from the axis to the circumference. The heavy point *A* tends to get as far as possible from the central line; and it can do this only by twisting the pulley in the direction of the arrow *A*, Figure 198. But the point *D* being extra heavy tends to bring a strain on the shaft in the direction of the arrow *D*, Figure 198. If that don't tend to bend a shaft then I know nothing of mechanics.

Suppose that instead of adding weight at *D*, diagonally opposite to *A*, a piece of the proper weight had been taken out at *B*, on the heavy side but on the opposite edge from *A*. That would also give a good standing balance; but its only effect when the pulley was running would be to intensify the twisting action of *A*.

But suppose that instead of adding weight at *D*, diagonally opposite A, it be added in sufficient amount (just the same amount as would be necessary at D) at C, diametrically opposite A. It would of course give proper standing balance; and when the pulley was running at high speed it would tend to throw the pulley in the direction of the arrow C, Figure 199, or to bend the shaft exactly in the opposite direction from that in which the weight at A tended to bend it; and the balance thus obtained could be perfect.

The best results will be got if instead of running the pulley on a horizontal shaft it be balanced on a cock-head as shown in Figure 200, in the manner of a millstone; the pivot being at its absolute center of bulk; that is, not only in the actual line but in the plane that divides it in two at right angles to the shaft.

These same remarks apply to balancing fly-wheels, millstones, etc., as well as to ordinary driving-pulleys.

Hanging up a Clutch Pulley. In these days of high-speed shafting there is needed a frictional clutch

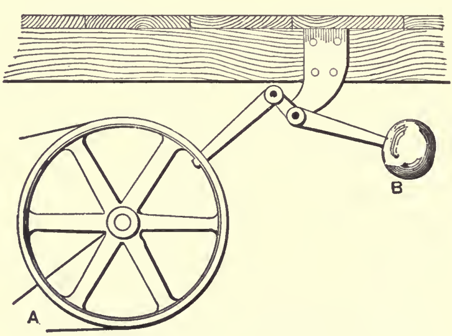


FIG. 201.—HANGING UP A CLUTCH PULLEY.

wheel that may be set loose or connected with the shaft. Where a machine is used about once a week for an hour, and the loose pulley is wearing the shaft all the rest of the time, there seems to be an unnecessary percentage of waste of friction. To do away with this there has been devised an arrangement having a counterpoise hung from the overhead floor-beams, to be attached to the pulley when it is brought to rest, so as to take the strain from the shaft. As the tendency of the belt-pull and the pulley-weight is to exert a force in the direction shown by the line *A* in Figure 201, the remedy is to apply an equal and opposite force to the wheel by a lever and counter-weight *B*.

Loose Pulleys as ordinarily made without any flanges are apt to cut the edges of the belt. The best form is that which I first saw about 1876; the loose pulley being very much smaller than the "tight" one but having a beveled flange leading up to the same diameter as that of the latter. The belt runs

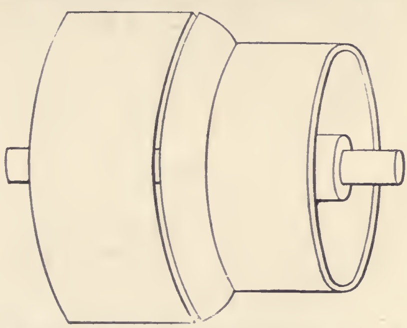


FIG. 202.—COMMON SENSE LOOSE PULLEY. (CRAFT.)

on this quietly, and with but little tension; and but very slight motion of the shipper is necessary to cause it to climb the beveled flange.

A less desirable form has, instead of the beveled flange, one at right angles to the face of the loose pulley, and of the same diameter as that of the tight one.

Keying Pulleys on Shafts. Over in England an American mechanic who has established a big shop near Manchester has got up a new way of keying pulleys and such things on shafts. Instead of making a shallow groove in the shaft, parallel with its length, and one in the pulley-hub to correspond, and putting in a key that runs lengthwise of the shaft,

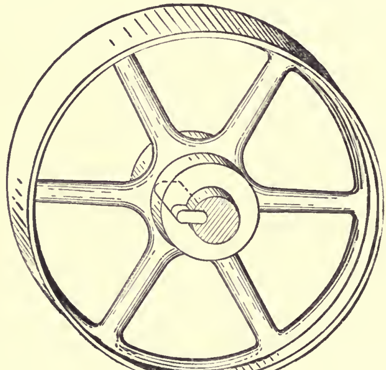


FIG. 203.—KEYING PULLEYS ON SHAFTS.

he cotters deeply into the shaft, making a narrow groove with rounded ends, that runs lengthwise of the shaft; and making a similar deep cotter-cut through the hub, he puts in a flat steel key with rounded edges at right-angles to the shaft. He has a machine which makes such cotter-grooves of several standard sizes, and another one which makes the keys of standard sections and cuts them off to convenient lengths; so that all that is required to do is to mark on the drawings "No. 5 Key," or whatever size it is. Then the work of cottering can be done without any special instructions, and the key can be taken out of stock in the same manner as wire nails are.

A Split Pulley by all means. Do you want to have to stop the whole shop every time you want to change a pulley? How else are you going to back out that long line of shafting, loaded up with solid pulleys? Don't you know that a large split pulley can be put up with less labor and in shorter time than a solid one?

Too Much Adjustability. There can be such a thing as too much adjustability. There are many cases where it is very useful to have a means of taking up wear or lost motion; but if such a means is open to the objection that when a part is once brought into its proper place it cannot be kept there, the adjustability may be a cause of damage instead of saving and convenience. For example—we have the hangers of tight and loose pulleys. In order to enable the excess of wear of the boxes in one end over that in the other to be taken up, such hangers are often made with slotted palms; but there is nothing easier than for the pulley of the belt (usually excessive) to draw the hanger around just on the very end where wear is likely to occur anyhow, so that, unless such hangers have a means of fastening them when once aligned, they will slew around and give trouble. If the makers have not done this for you, you will have to do it for yourself by drilling a small hole through which to pass a bolt, lag-screw or other locking-device. If the hangers are already up, and trouble is found with their slewing, then a chock of hard wood may be screwed on the timbers so as to receive the thrust of the palm and keep it in place.

Why Most Planer-Belts do not Last Long. One reason is that their edges are spoiled by the constant action of the shifter; and the same may be said of many other belts which are shifted by the ordinary pole or by even a regular shifter. To lessen the wear

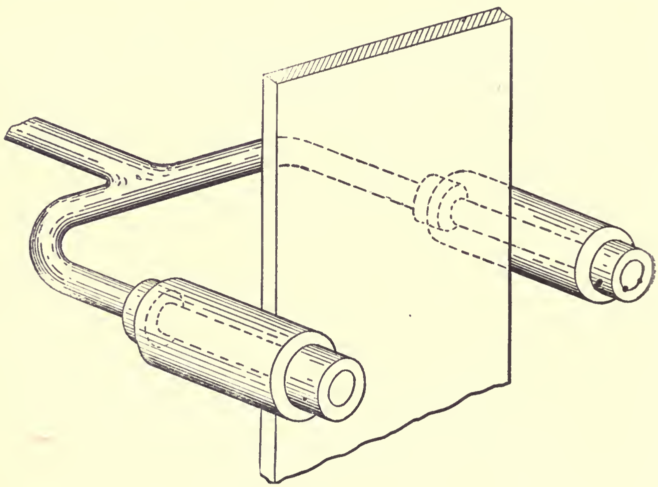


FIG. 204.—PLANER-BELT SHIFTER.

and tear and prolong the life of the belt, make the shifter to bear against the edges of the belt by grooved rollers or wheels instead of by a *bare* edge; the wheels of rollers will rotate and be easy on the belt-edges.

Belt-Shifter. For a belt-shifter which will always be in place and will cost little or nothing, the rig shown in Figure 205 may be recommended. Its upper end has a slightly hooked point which may be inserted in any one of several holes having a distance between centers equal to that between pulley-faces,

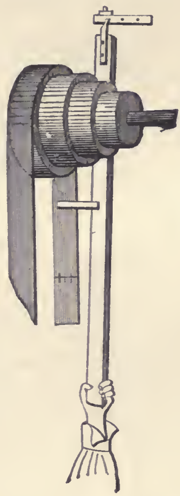


FIG. 205.—BELT-SHIFTER.

where there is a stepped pulley. According to which pulley the belt is on, this hook is inserted in the proper hole.

Belt-Handler. The device shown in Figure 206 is handy for putting a belt on a pulley without danger or inconvenience. Any one who has reached out for a belt with an ordinary pole (the ones which are at hand usually seem to have rounded ends so that their hold of a belt is reduced to a minimum) knows how many trials are often necessary before a running belt that has been thrown off can be lifted from the shaft and got to remain on the pulley so as to drive it. One's strength is not exerted to advantage under such circumstances, and one's temper is surely tried to its utmost. If the belt is somewhat tight and its motion rather rapid, the difficulty is increased.

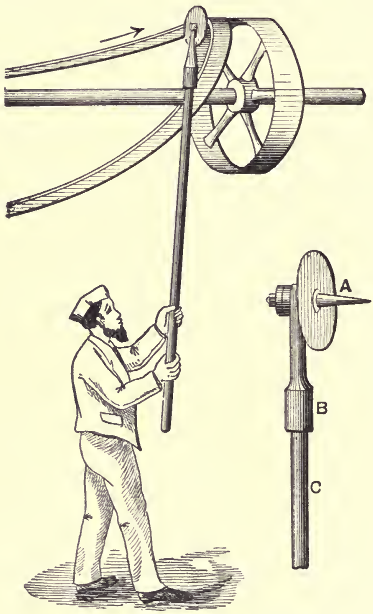


FIG. 206.—BELT-HANDLER.

The contrivance shown here is an English idea for the good working of which I can vouch, having made, used, and sold such shifters in this country. The wheel *A*, with a spike in its center, rotates easily in a journal on the socket *B* which fits on a pole *C*.

A Combined Belt-Shifter and Brake for such machines as vertical jig-saws has a brake so fastened to the lever of the belt-shifter, as to rub against the flat side of the fast pulley, after it has thrown off the belt.

Transmission by Gearing. It is not enough that the teeth of a pair of gear-wheels simply seize hold of each other, and that the pressure from one set forces the other set around. This action must be smooth and regular, and not by fits and starts; ought to be practically noiseless; should be accompanied by a minimum of wear, and not occasion crowding apart of the wheels, which would cause great axial friction; this last being co-existent with wear of journals and bearings, waste of lubricants and loss of power. And under average circumstances every gear of a given pitch should mesh properly with every other of the same pitch, from rack to pinions as low as twelve teeth.

A Wrinkle About Gear-Wheels. You complain that your gear-wheels wear irregularly. That is very largely owing to the fact that the number of teeth in one is a multiple of that in the other. Every so many turns, the same pair of teeth come together. It happens that some of the teeth are harder than others; and every so many turns you have a hard tooth wearing against a soft one. Now, if the teeth were "prime" to each other, as for instance eighteen and nineteen, or eighteen and thirty-one, or any other pairs of numbers which had no common divisor, you would find that they would last longer; and in this case there is no more need for having eighteen to thirty than eighteen to thirty-one.

Diametral vs. Circular Pitch. Replying to the question as to whether the pitch of gearing should be diametral or circular, one large Eastern machine-tool builder says: "We see no reason why a proposed standard should exclude either diametral or circular methods. The diametral pitches, 16, 12, 10, 8, 6, 5, and 4 per inch, afford all needed variety by a suitable progression. They are exceedingly convenient as regards shop measurement, and (what is more to the purpose and a *result* of the preceding) they are in universal use, and will assuredly be used, whether recognized by any standard authority or not.

"The diametral pitches intermediate to the above are not needed for variety, or, at least very rarely, and introduce to the workman awkward and unaccustomed fractions, while larger pitches in suitable progression by the diametral plan are increasingly open to the same objection, and the convenience of the system disappears.

"Were we now to adopt for ourselves a system of pitches they would almost certainly be diametral to four per inch, using the numbers above, and circular for larger pitches, by eighths from $\frac{7}{8}$ inches to $1\frac{3}{4}$ inches or 2-inch pitch (inclusive), and by quarters above 2 inches."

The Nordyke & Mormon Co. thinks that for cast gearing, such as for mill-work, etc., the circular pitch is best, and suggests that the progression should be by $\frac{1}{8}$-inch in advance from $\frac{1}{2}$ to $1\frac{1}{2}$-inch, then by $\frac{1}{4}$-inch advance to $2\frac{1}{2}$-inch pitch, then by $\frac{1}{2}$-inch advance.

Cut vs. Cast Gears. In reference to the comparative advantages of cut versus cast gears, I may say in favor of the former that the teeth being much more correct and regular in outline and more uniform in size, with less back-lash or play, they run much more steadily and smoothly, and with less friction than uncut gears do. There being no draft, the wheel has no "right and left" as with pattern-molded wheels. But there is this to be said for the uncut, that the skin of the casting remains intact, and the material is more resistant to wear than if the softer material were exposed.

In the matter of large cast gears, those which are machine-molded should have the preference over those cast from a whole pattern, because the teeth can be made more carefully, and molded more perfectly; the draft being less and there being no twisting of the pattern. Of course, after the index machine and appliances are provided, the machine-molded gear is much the cheaper to produce. The draft is but slight, which is an advantage.

Overloaded Gears. Gears are more apt to be overloaded than belts are, because they will not slip as belts will, and will either break or cut out.

Strength of Gear-Teeth. The thickness of teeth at the pitch-circle may be considered as an average of the thickness at the root. Where wheels have straight flanks (generally owing to the fewness of teeth) the thickness at the root is less than at the pitch-circle. In most other cases it is greater. In calculating the thickness and breadth of teeth, there must be considered not only the question of the strength of the teeth, but their resistance to wear by abrasion resulting from sliding friction.

The faster wheels run, and the more suddenly they are started, stopped or reversed, the higher should be the factor of safety.

Dimensions of Gear-Teeth for a Given Power. It will very probably be impossible to establish any general rule for the proportions of gears to transmit a given horse-power, because the horse-power transmitted seldom gives us any knowledge of the greatest strain to which the gearing is liable. Belts relieve themselves by slipping and stretching; shafts by twisting and springing; gears by *breaking*. Bements consider it safe to apply at the pitch-line of good cast-iron gearing a strain in pounds equal to 1,000 p^2 to 1,200 p^2. This supposes ordinarily favorable circumstances, and a face width of about 3 pitches.

There are cases where a greater strain is safe, and others quite the reverse. Perhaps the best way on this subject is to treat every important case on its own merits.

Proportions of Gear-Teeth. These vary according to the purpose for which the gears are intended, and the materials of which they are made, and are to a certain extent independent of the tooth outline. The pitch being 1, the depth to pitch-line may be 3-10, working depth 6-10, whole depth 7-10, thickness 5-11, breadth of space 6-11. (Willis.) One English proportion is: pitch 100, depth 75, working depth 70, clearance 5, thickness 45, space 55, play 10, inside pitch-line 40, outside 35.

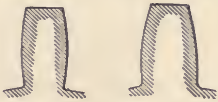
The manufacture of gear-cutters (not gear-cutting machines) by one or two large firms has done and is doing much to unify the practice as to outlines, and dimensions of cut gears. The cutters of these firms are exactly alike in these particulars, except a difference in bottom clearance, so trifling as to be of no consequence, and the same proportions would be best adhered to for teeth of circular as for diametral pitch. For the former the working depth would be 0.64 the pitch (correctly 0.63662), and the bottom clearance 0.5 p. In the matter of width of face of cut gearing, probably no standard would be possible or necessary, as it is so often dependent upon circumstances. Three times the pitch is, however, by many considered a very satisfactory width.

Small teeth require proportionately more clearance at the root than large ones.

In order to reduce to a minimum the cutting of a shoulder in the flanks of epicycloid teeth, D. K. Clark recommends, if the flanks have excessive taper, thinning the teeth for a distance of half the hight of the flank, measured from the root; stating that the working durability of the tooth is much increased, and steadiness of action promoted even when the tooth has become much worn.

Gear-Tooth Outlines for General Adoption. If we are going to have a gear-tooth outline which shall be understood to be the standard and be by law so recommended and adopted, it would be well to consult all the great builders and designers of machinery. To a certain extent I have done this in days gone by.

Special Gears. While there should be standards of gearing to which it will be understood that any maker will cast or cut gears when ordered without any specific directions, yet it is well to remember that for special cases it is best to use special gears, just as for



FIGS. 207 AND 208. (FRED. J. MILLER.)

special purposes particular non-standard screw-threads may be desirable. Where a machine is needed for a purpose calling for but little power, but in which friction should be eliminated to as great an extent as possible, it will be well to follow the suggestion of Mr.

Fred. J. Miller and use an epicycloid tooth the curves of which are generated by a rolling-circle of greater diameter than the pitch-radius of the wheels, thus getting a tooth-outline about like that shown in Figure 207—not a pretty tooth, and not a strong one, but rolling easily with its mates. But where very strong teeth are needed, and especially if the pinion is of comparatively small diameter, the rolling-circle may have a diameter smaller than the pitch-radius, producing such a tooth, for instance, as is shown in Figure 208.

To Lay off Teeth for a Sprocket-Wheel of any diameter, where you have the chain already, first find the distance between links of the chain; this will determine the pitch of the teeth of the wheel, and this pitch of course must be constant for every wheel with which the chain must work. Note the number of teeth that any one wheel must have; multiply the pitch of the chain by that number and divide by 3.1416 (unless you have a tape-measure which is graduated into units of 3.1416 inches in length, these units being marked 1, 2, 3, etc., to show the diameters in inches of bodies about which the tape-measure is passed). Lay down a circle of this diameter, which diameter will be the pitch-diameter or working-diameter of the wheel, measured at a distance half the thickness of the links from the bottoms of the teeth. Draw a circle smaller than the pitch-circle, by the diameter of the links; then there will be between it and the pitch-circle a space equal to half the link-diameter. Step off either of these circles into as many equal parts as required for the number of teeth. About the points of division on the pitch-circle, as centers, draw circles having a diameter equal to that of the chain; then between but not cutting these circles you may lay out the teeth, with as great a spread as will give strength at the base, but without making them so pointed as not to get a good grip on the links.

This rule assumes what is ordinarily the case, that the links will curve slightly to conform to the pitch-circle.

Spur-Gear Blanks. There are still many machinists and millwrights who learned, as I did, the old-fashioned "circular pitch" for gear-wheels; and many of these may be, as I was for some time, bothered about coming over to the "diametral pitch" system now so largely adopted. For some of these, and for those who have come here from other countries and are still thinking in the old systems, I may say that the diametral pitch of any gear is the number of teeth that it has to each inch of diameter on the pitch-circle, and that the blanks are always of the same denomination as the pitch; thus an "eight-pitch" gear must be a certain number of even eighths of an inch in diameter; a "six-pitch" gear always certain even number of sixths of an inch, and so on.

To find the outside diameter of the blanks for spur gears, add two parts of the pitch to the diameter of the pitch-circle. Thus for an eight-pitch spur gear of thirty teeth, the outside diameter of the blank is 32 eighths or four inches; for a ten-pitch gear of forty teeth the outside diameter of the blank is 42-tenths=4.2 inches.

To get the distance between the centers of two gears, add together the number of teeth and divide the sum by double the diametral pitch. Thus if there is a 48-tooth and a 36-tooth spur gear working together, both being five-pitch, 48 plus 36 equals 84; this divided by twice 5 equals 8.4 inches, the distance between centers.

Planing Bevel-Gear Teeth. Milling bevel-gear teeth is an absurdity if one expects to get teeth that will mesh together without heating, rattling or backlash. Any cutter that has the right profile for the back end of the teeth—that is, the large part of the wheel—would not of course leave tooth enough at the other end. On the other hand, a cutter that is right for the small end would be of no use for the large, as it would only make an approximation to the proper outline, to do as some do, run through twice, once for each side. For such wheels, in the first place, the ordinary

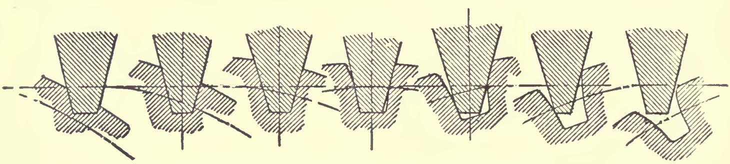


FIG. 209.—PLANING GEAR-TEETH. (BILGRAM.)

involute and epicycloidal tooth outlines are almost impossible to get up even at the greatest expense; and in the second place with ordinary machines and ordinary workmen they are not feasible. The system that works best for bevel-wheels (including both miter-wheels proper, or those with forty-five-degree angle, and other bevel-wheels, having different face-angle) is one in which, instead of the pinion of twelve to fifteen teeth, the rack is the "master" with which all others of the system will roll. With the ordinary standard gears, such as those of Pratt & Whitney and Brown & Sharpe, all wheels of a system will gear properly with the master-pinion of fifteen teeth and consequently will mesh properly with each other; and in the Willis system the master-wheel is a pinion of twelve teeth, which is the pinion of the smallest number of teeth that can be cut and leave any strength in the tooth-flanks.

Going to the opposite extreme we find that we can employ as a master-wheel one having an infinite number of teeth—that wheel being, to make an Irish bull, a rack; and all wheels of a system that will gear properly with the rack will gear properly with each other.

Now the rack itself, or one of its teeth, may be used as a cutter for all spur-wheels or gear-wheels of the system; and Figure 209 shows how the teeth of an involute rack would cut its way through a rolling blank, forming one of the spaces of the teeth. (The dotted line represents the pitch-circle.)

Now if you have a tool representing one tooth of a rack, and having a reciprocating motion while the wheel-blank is given a rolling motion, we may make bevel-gears which will mesh properly together. As the involute tooth is the only one which will mesh properly at varying pitch-diameters, the involute rack tooth, which has straight sides, is the only one available for this purpose. In using it the tool must not run parallel with the pitch-cone, but with the bottom of the space. In the Bilgram shops, Philadelphia, all bevel-wheels are cut on this system, on a special machine consisting of a "shaper" with an attachment for holding the blank and giving it not only intermittent rotation to suit the desired number of teeth, but a rolling motion like that of a conical pendulum; and I have seen bevel-gears, made on such a machine, consisting of a set of 12, 18, and 24 teeth respectively, all meshing with one of 36 teeth. Of course the axis of the 12-tooth bevel pinion was much nearer to the face of the 36-tooth wheel than that of the 18-tooth pinion, while that of the 24-tooth pinion was farther away. This would be a case practically impossible to make on any other system; but here it is done; the tool automatically easing away just enough of the backs or back ends of the teeth on the 12-tooth pinion, and just enough on the small ends of the 24, to make perfect rolling contact. By the same system, inclined-teeth wheels (not skew wheels, where the axes do not come together if prolonged) may be made, giving continuous contact as with the "herring-bone gears" used in rubber-mills (and not enough used in other work) to insure that there is always one tooth in full mesh.

False Teeth for Spur-Gears. It often happens that by reason of its being too weak, or having the load brought on it diagonally instead of squarely, or of something getting in the way, a tooth will break out of a large spur-gear; and the smaller the diameter of the wheel with reference to the pitch, the more trouble this will make in driving, especially if it is the driven gear. But it is not always necessary to put in a new section of rim, even where provision has been made for this. You may put in a false tooth that will be even better than the original, by making a tin template of one of the others (allowing the proper amount for what has been worn off, if you wish and feel competent), and on its bottom marking off a dovetail. Make a wrought-iron tooth to this template; slot out the rim with a portable key-seating machine, or if you have not this, chip it out; then fasten the tooth in place by two or more bolts or studs from the back, or by studs from the end of the tooth.

Instead of a wrought-iron tooth, one of gun-metal may be used—and by "gun-metal" I mean either "8 to 1" copper and tin, or what is known in South Boston and in Pittsburgh as gun-metal—namely, an excellent quality of cast iron such as was used for making "Parrott" and "Columbia" guns.

Grinding Cast Gears Together. There is a much-maligned animal called the jackass. Whenever any one does anything that is not just right, or which some one else thinks is not just right, he gets called a jackass; whereas in many cases it is a libel on the four-footed animal. It would be so in the case of the so-called machinist who grinds his cast gears together to make them run smoothly. In order to do the thing about as badly as possible, he uses emery or corundum to help the grinding along. The result is that if the teeth ever had any regular shape, or any form at all, other than might be made by getting the print of the ball of the thumb—that shape is all gone. The action of the gears may be smooth enough as regards absence of noise, and as regards freedom from hard running; but if you will set together a train of several such gears and see that the first of them is turned slowly, one tooth at a time, with regular velocity, you will find that the last one goes by fits and starts, according to just what parts of the teeth are in gear; and the smaller the pinions in comparison with the spurs, the greater the irregularity of motion. In addition to this, you cannot grind cast-iron surfaces together with emery or corundum without some of the abrasive getting bedded into the metal, there to remain acting as in a lap, cutting and scoring its way into the opposing surface and thus producing a heating worse, if possible, than the mere roughnesses that were considered objectionable.

Not that rough gear-teeth are to be praised or even countenanced; but the best way to do is to get them smooth, regular, and of proper outline at first, by making proper drawings and having proper patterns; by taking care in rapping the patterns when making the mold, and by being careful to use the proper metal and to pour it rightly. Then the tooth-curves will be such as to ensure regular action, and the surfaces will be such as to run smoothly; while the skin of the castings, which is the best part of them, will not be taken off before the wheels are put to work.

A better way than to make patterns of large wheels is to make a good template and make the mold by a gear-molding machine, with a good index-plate and stiff radius-bar.

Wooden "Core-Wheels" sometimes give trouble by the keys becoming loose and letting the cogs rise in the mortise, breaking the gear. Core-wheels cogged with dry material have been known to burst by the swelling of the cogs in their mortises.

Raw-Hide Gears. Many years ago it was well known among millwrights that raw-hide was one of the most desirable things in existence, and that gears made of it would outlast most metal and all wooden ones. Since the introduction of electric street-cars, there has been a demand for something that would be more durable than bronze, cast or wrought iron, or even than steel, and that would not howl as metal ones do under the high speeds requisite for street-car motors. Here raw-hide gears come in with special advantage; not only wearing longer themselves than metal ones, but prolonging the life of the large metal gears with which they mesh. They require no lubrication—in fact are better without it than with it; and they greatly reduce vibration. On electric-motor shafts this is of special advantage, as it makes the armature-wires last longer. Steer hides are the best for this purpose, and the butts are the best parts.

Testing Gear-Teeth. In all machine-shops that are specially rigged for cutting gear-teeth on modern principles, there is provision for measuring the teeth with compound vernier calipers especially constructed for this work, and enabling the measuring of the distance from the top of the tooth to the pitch-line within one-one-thousandth of an inch, at the same time measuring the exact thickness at the pitch-line. In the Leland & Faulconer shops there is a spur-gear tester which carries two studs that are exactly perpendicular to the bed of the machine, and is provided with a vernier which enables the testing of the gear at precisely the correct center-distance. Their bevel-gear tester has two spindles exactly perpendicular to each other, and the center-lines of which are in the same plane.

Figuring Gear-Teeth. The way that Lee figured up the number of teeth in a wheel which he needed, to cut a screw of one-and-one-half-inch pitch, with a compound-geared lathe, was not by figuring, because every one who figured on the job told him a different number; but he put on the gear to cut one-inch pitch; took up all lost motion, marked the carriage and face-plate, put a two-foot rule with one end on the floor and the other on the third change of wheels, made a scribe-mark above the rule, went to the face-plate and moved it until the carriage had moved one and one-half inches on the bed, went back to the gearing, made a second scribe-mark on the same wheel, and noted the number of teeth in the wheel between the scribe-marks. Then he told the foreman that he must have a wheel made, with twenty-five teeth instead of twenty-eight. It was ordered and made, and when put in place made the worm with one and one-half inches pitch.

All of which shows that some men have ideas in their heads.

Rules for Laying Out Gearing. *To determine the stress per-tooth of a cast-iron spur-wheel transmitting a given horse-power.* Multiply the number of horse-power by 129,050, and divide the product by the diameter in inches, times the number of turns per minute.

To determine the pitch and breadth of face of a cast-iron spur-wheel transmitting a given horse-power. Divide the stress on a tooth, in pounds, by the number of pounds strain per inch breadth of face.

Shown in the following table :

Pitch, inches	¼	⅜	½	⅝	¾	⅞
Pounds stress per inch breadth of face.	20	30	40	50	60	70
Pitch	1	1¼	1½	1¾	2	2¼
Pounds	80½	100½	120½	141	161	181
Pitch	2	2¾	3	3	3	3	4
Pounds	201	221½	241½	261 1-16	281½	302	322

This gives the breadth of face in inches. The figures of permissible strain are low, but are based on average shocks, and are suitable for oblique strains.

To get the exact radius of a pitch-circle, in inches. Find the exact radius, nearest to the approximate radius, that with the given pitch will evenly divide the pitch-circle. The number of teeth will be equal to 6.2832 times the assumed radius, in inches, divided by the circular pitch, in inches. Taking the nearest whole number to this quotient, the exact radius, in inches, will be equal to the product of this by the pitch, divided by 6.2832.

Troublesome Bearings. Sometimes there comes back to the shop a bearing that will heat, no matter how much oil it gets. It is strange, but true, that in such cases relief will very often be got by simply changing the bearing-metal. If it is a brass bearing that heats, a babbitt bearing will often work all right, and this with no discredit to the brass, because it is very often just the other way about; the brass may run cool where the babbitt will melt out. No one as yet can tell just why this is in any one instance; there are about seventeen different things that go to make up the reason, or the set of reasons, why the thing will not run cool. Just put it down to "the nature of the beast," and try something else. I have known apple-wood to run cool where babbitt and brass both failed; and *vice versa*.

Cool-Running Bearing. After all, about the best bearing for a circular-saw arbor or anything like that, which gets bad usage and plenty of it, is the rind of salt pork. That will help you out of the difficulty, in nine cases out of ten; but when you have time and opportunity, you should put in something more substantial and workmanlike.

"Self-Oiling" Bearings. Do not place too much (that is, entire) dependence on self-oiling bearings. While their use is to be recommended, it is to be remembered that there is no device of either human or Divine design and construction that is not liable to give out at some time or other; and luck usually brings the times of failure just when they will cause the most inconvenience or loss. A safety-valve is supposed to be a self-acting device to prevent boiler explosions, but none the less is it practically imperative that it be tested daily to see that it lifts easily; and in the same way with a self-oiling bearing; it should be given frequent and careful inspection to see that some one has not neglected it or tampered with it, or that it has not for some reason or other (or no reason at all) stopped working or commenced to work imperfectly. This is particularly so on crosshead bearings; they are especially liable to get out of kilter, and when they do they take less time to seize and give less warning than almost any other kind.

A very simple type of "self-oiling" bearings may be made by providing in the cup a recess formed by a circumferential groove, in which there is placed an endless rope or chain that dips in the oil receptacle below and is turned by the motion of the shaft. The faster the shaft turns, the faster the oil is brought up.

Cast-Iron Bearings. When you get right down to it there are many things to be said in favor of cast iron working on cast iron, and wrought iron on cast iron. In how many shops do you see wrought-iron shafting running in ordinary unbabbitted cast-iron bearings, and doing it day in and day out for years without any trouble, as long as they are only decently lubricated? Take a Sellers planer. Here is a cast-iron worm working in a cast-iron rack. The only special precaution which is taken in this case is that the worm is not cut by the use of the lead-screw, but a standard former is used; both the former and the worm being on the same mandrel, and the nut which gears into the former being fast to the carriage which carries the tool for chasing. This makes it certain that the worm will be as correct as the former; and if the former is properly cut the worm must be right.

Ball Bearings. In olden days wherever there was a rotating piece, it turned on cylindrical journals or gudgeons; usually short and thick. With some advance in the science and art of mechanics, cylindrical bearings became longer and longer, thus lessening the pressure per square inch which tended to squeeze the lubricant out from between the bearing-surfaces. A further development was in the nature of anti-friction rollers; and for a long time the homely and primitive grindstone was away ahead of the best other grades of machines in having these. The use of the cone-center for certain classes of horizontal rotating-pieces, as in lathes, was a great step; and both the lathe and grindstone were examples of advanced, although no further advancing, practice.

The anti-friction roller was an advance in that it substituted rolling for sliding friction in carrying most of the load; the sliding friction being only that of the journals of the rollers instead of that of the main journal. The cone-centers were examples of relying on hard and perfectly-formed bearing-surfaces instead of on large areas.

The ball bearing is, to a certain extent, a combination of the two; employing harder bearing-surfaces than could be practical with any other system, and substituting rolling for sliding friction. It is time that ball bearings or their kin, freely-running roller-bearings, were more used in large machinery. Their complete success in bicycle construction should shame mechanics who are engaged in what they term heavy standard work.

Recent improvements, such as electric welding, and ball-rolling machinery, enable turning out steel balls of great hardness and smoothness to a very close approximation to perfection in sphericity; and improved grinding machinery enables bringing them to a still higher degree of perfection in shape and surface. Improved grinding machinery also enables the production of grooves of either V or semi-circular section, with a high degree of correctness in the circumferential direction, and of surface; so that there are now at hand materials formerly lacking, and which invite the designer and builder to use them with credit to himself and satisfaction and profit to the purchaser of the machines using improved bearings.

Ball-and-Socket Bearings. The less you have to do with a ball-and-socket bearing the better you will like it. When both the ball and the socket wear, they wear to different radii; and then there is no adjustment which you can make, give or maintain, which will produce a full bearing between the two surfaces. Theoretically, the contact will be but a single point. Practically, it may be several pinching-places. In either case it will be no good.

Turbine Steps. Turbine steps often make a good deal of trouble by giving way just when least expected and most troublesome. Outside of the question of stopping the mill and of cost of replacing the steps themselves, often there is damage done by stripping bevel-wheel teeth, especially where they are of wood in mortised iron rims.

Of course, if these steps were all right, and everything else was all right, they would not burn out or otherwise give way; but the main thing is not merely to know this—which is practically self-evident—but to note just what the causes are and how to prevent such happenings.

The principal causes of steps burning out are improper material and design of the steps themselves, foundation and setting of the wheels, penstocks and draft tubes; defective lubrication in the case of those

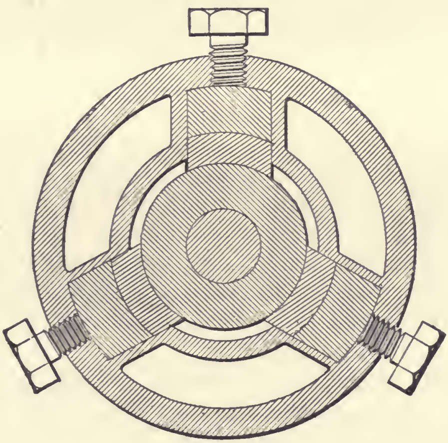


FIG. 210.—ANTI-FRICTION TURBINE STEP.

that are not exposed to the water, and lack of care in keeping things generally lined up.

As to material: lignum vitæ is that usually chosen; but all is not equally good, and some pieces are harder on one side than on the other. If one side is more durable than another it must be expected that the softer side will give way first; then there will no longer be a good wearing-surface and the steps will give way. Boiling the wood in oil improves it in every way.

Very often the shape of the step is such that the outer part of it gets more wear than the inner; both the toe and the step going faster towards the circumference than at the center. There is a form of bearing known as Schiele's anti-friction bearing, which is used by some builders of machine-tools and in which the pressure per square inch on the circumference, where the speed is higher than at the center, is less than at the center. This principle might be employed with advantage for turbine steps. Some years ago I proposed such a step-bearing and illustrated it in the *American Miller*, I think; but the one that I proposed was duplex—that is, there was one such bearing rotating in another one of the same character, so that if either of them should cease the other would take up the rotation. This would also lessen the comparative rotation-speed. See Figure 210.

In many cases a large proportion of the weight of the wheel could be taken by a collar on the shaft, above the wheel, and running on ball bearings; reserving the step as a means only of insuring perfect centrality and verticality of the shaft.

But in the wheel-pit itself and the foundation and setting there is more affecting the wear of the step than almost anywhere else. Of course, if the step is under water all the time it will not burn out so fast as if there is an air-pocket formed, as is sometimes the case where there is a draft-tube; but under water or not, if the foundation goes down on one side, the step will get unequal wear and will go. The use of a plumb and level about the wheel will show whether or not the latter is out of plumb; but the wheel may be plumb enough and the foundation under the penstock may get down on one side locally, bringing the step and the concave together on one side more than on another, and soon cutting out the bearing.

Where the structure is on a gravel bottom (and still more the case where it is on sand) there is danger lest it be washed away; and planking should be put under the whole business, of large enough area to prevent the water getting under and having any washing tendency. Of course, quicksand is worse than sharp sand in this connection, for that not only washes away easily, but runs with the slightest provocation, on the addition or removal of weight from its neighborhood.

An excellent foundation may be made of piles driven to the rock or hard-pan, filled in between with broken stone, the spaces between these poured with coarse grout, and the tops of the piles (which should, of course, be sawed off level if very uneven) well planked over; or if the tops of the piles are not very uneven, coarse grout may be poured in to fill up to the level of the highest top, and then the planks may be laid down. When the grout is well set the penstock may be put up; and it is just as well that attention be paid to have full, even, plentiful discharge for the water, below the penstock and above the platform, so that there shall be no erosive tendency. The wider the tail-race the less the liability (other things being equal) to cut away under the platform and lower the step. The greater the velocity of the water as it leaves the wheel, the greater the necessity of having full area of discharge away from the structure; for although the water at the higher velocity will flow away more readily and with a smaller area of discharge, it is this rapid flow that it is desirable to counteract; and the flow should not be faster than one hundred feet a minute—requiring about a square foot of sectional area for eighty cubic feet of water or so, per minute.

Where steps are not submerged, graphite will be found to be a good lubricant; it should be introduced before the wheel is put in, and then the greater the pressure on it, the smoother it gets.

Until after the first spring following the setting of the wheel, the structure, wheel, shaft, etc., should be carefully tested with plumb and level from time to time, to be sure that it is not settling. If then it be found that there is no settling, it may be assumed that things will run along without much trouble from this cause; but none the less there will be demand for a proper step.

To Prevent a Foot-Step From Welding, let it run in an oil-box and drill a hole diagonally from the circumference to the center of the spindle, to let oil run out as explained by the so-called centrifugal force; then have radial channels in the bearing-plate to let oil run in from the receptacle surrounding both. This will keep a current of oil going from the bottom of the reservoir to the center of the contacting plane, and from there still upwards (but outwards instead of inwards), from the contacting plane to the circumference of the spindle.

Where much trouble is given with turbine foot-steps welding, it may usually be remedied by welding on the lower end of the shaft a disk having its central portion recessed, and letting this bear on a large plate. The central recess serves as an oil-space. Excess of size of the plate makes too rapid frictional speed. There should be curved grooves like millstone furrows, and the oil should be fed into the plate from below.

Oil-Saving. There is too much oil used; and aside from that which is used there is far too much wasted. By this distinction I mean that there is a certain amount that is absolutely necessary in order to keep the bearing-surfaces cool and free from cutting. This quantity varies with the material, dimensions, design and condition of the bearing-surfaces, and consisting properly of oil that is used, and which cannot be cut down by any degree of knowledge, skill or experience on the part of the engine-runner. Then over and above this there is a certain amount that is wasted by reason of the fault of the engine-runner, by irregular or excessive lubrication, or by the habit of slushing up at one time and letting run almost dry at another. The proof of this is that when premiums are offered for oil-saving on railways the amount is brought down and kept down, while trains make the same mileage and time, the bearing-surfaces are kept in just as good condition and the fuel required is no greater, in some cases is even less. Such a condition of affairs having been brought about by full knowledge and care on the part of some one engine-runner or several, the threat of discharge in case the oil-consumption is not brought down to a certain maximum by those who have no incentive to saving or who don't appreciate the incentive enough to work for it results in the general consumption being lowered and kept low.

A good deal of the oil that is wasted is just thrown away by being squirted about and put anywhere except where it is needed; also allowed to leak from supply-cans.

Once the average amount required for certain engines, grades of service, and runs having been determined, by experiment, it may be kept there by allowing each class of engine a certain maximum supply for a given run and cutting the size of the supply-cans down to that, with a slight margin for emergencies, while making the daily supply just the average consumption without any such emergency allowance. If the engine-runner or the fireman is allowed to draw his own supply for each day or run, it will usually be found that he will take more than he could get along with if it was measured and furnished by some one in charge of the oil.

If hand and feed-cans are allowed to get leaky or broken, and the ends of long spouts are let get battered out of shape or enlarged by breakage of the tips, the oil-consumption will be increased.

It will be found that a small amount regularly applied will keep bearing-surfaces from getting heated, while if they are let get hot it will take more than the amount saved to get them cool again, or to enable them to run without seizing. Then if, instead of running cool without a certain amount of oil they merely run without seizing, there will be more friction; the engine will "haul hard," and the coal-consumption will be greater—to say nothing of the life of the bearings themselves. The same thing applies to rate of running; the man who jogs along at a regular schedule rate will require less oil than the one who over-runs and then lags back.

Changing the quality of the oil often results in loss, not by reason of the new oil being any worse than the old, but because the conditions of tightness of fit, etc., with which it works best, are different.

Some oils are limpid, and will work their way in between surfaces that are very closely fitted; others may be better, but if they cannot get where they are needed, they will not give so good results.

Some oils will give better results than others at a certain speed or pressure, and above that or below that they will not do so well. In the same way some cylinder-oils are better than others up to a certain steam-pressure, and above that they are not so good —they "go to pieces," as it were.

I have even found that some oils will work well with dry steam, that will not work with wet, and *vice versa.*

The engineer who wants to save oil to get maximum results should keep his eyes open and have a good note-book.

Wrong Lubricants. Very often a bearing is all right in itself, but the lubricant is wrong; for instance, good thing that graphite is, as a lubricant—none better, take it all in all—it will not flow well through oil-holes, even when mixed with thin oil; and sometimes the very cooling of a bearing will cause graphite that has been mixed with the oil to clog up in the hole, to an extent that is not remedied by the heating of the bearing, owing to the stoppage of lubricant.

Oiling Pins From One End Only. A special pin in a fly-wheel governor of the Straight Line Engine Co. has a bearing at each end that requires to be oiled from one hole, and that at one end of the pin. The annexed illustration shows how that is successfully accomplished. The pin is bored very nearly through its entire length; at the far end of the bore there are four holes leading to the bearing, and there are also four similar holes near the out end, having similar outlet. To insure equal distribution of the oil to both sets of holes, there is a smaller concentric tube leading from the accessible end and terminating at a point

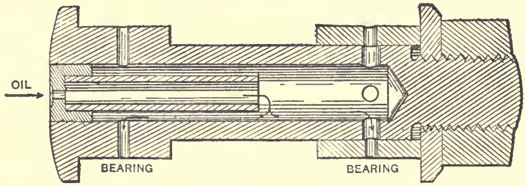


FIG. 211.—OILING PINS FROM ONE END ONLY.
(PROF. J. E. SWEET.)

midway in the length of the pin. The oil introduced at one end flows to the middle of the large bore-hole, and thence goes in both directions to each set of holes.

Sight Feed. To get just the right amount of feed from sight-feed oil-cups, try various amounts until you get a trifle more than is necessary, and then mark a very fine scratch on the head of the feed-stem. That will indicate the right amount for that kind of oil. If you change your oil, it may or may not be right, according to the viscosity of the oil.

Floods of Oil. McAdam is mad. McAdam's former engineer wants a job. The reason is that McAdam put in an oil-tank that had a faucet at the bottom, and the engineer left the faucet partly open over night, so that in the morning there was a small lake of cylinder-oil on the floor of the engine-room. Jurgensen's oil-tank has a little pump so that when the engineer wants any oil he has to work for it. Jurgensen don't lose oil the way McAdam has done.

Pumping Gritty Water may be better done with leather-faced valves than with those of hard rubber. This latter material is all right for clear water, but not serviceable where it is muddy and gritty. A sole-leather facing may be added temporarily to ordinary hard-rubber valves for this purpose.

Cup-Leathers. The name of the inventor of these has escaped me, if I ever knew it; which deprives me of the pleasure and privilege of abusing his memory. Any one who has had charge of renewing these ingenious and unsatisfactory devices, or of paying for their maintenance, will appreciate this. In nine cases out of ten, hemp packing put in a properly-shaped stuffing-box and liberally supplied with blacklead (so-called) before putting in will do just as well and cost much less; and in the tenth case it would do as well and not cost any more, "year in and year out."

But if you are already rigged out with these expensive luxuries, and circumstances will not permit a change outright, try the way that the Wm. Sellers Company introduced for hydraulic accumulators:—making the leathers closed instead of open V's; that is, turning in the adjacent edges and stitching to them a flat leather ring so as to enclose an area of **U** shape, filling the space with tallow and blacklead (which the wise call graphite). Then the greater the pressure, hydraulic or otherwise, the more grease and graphite will be squeezed through the pores of the leather, and the better the friction will be reduced.

Ten-Inch Suction Hose. Having occasion to furnish in a hurry some ten-inch suction hose with couplings (which latter I made in a very novel, cheap, and effectual manner as related elsewhere), I got a pine log about twelve inches in diameter, turned it cylindrically to a diameter of eleven inches, wound it with No. 4 galvanized-iron wire, about an inch pitch, and sprung this into a heavy sewed duck tube; delivering it to the customer with the caution to be sure that the ends of the wire were fastened to the couplings. It seems that this injunction was forgotten; for the day after the delivery of the hose and couplings, I got a message that the pulsometer was all full of wire. When this was with considerable trouble extracted, and new wire put into the hose, properly fastened at the ends, there was no more trouble. Such hose is so cheaply and quickly made that it seems strange that no one else has thought of using it, especially for emergency jobs. I could sell it at $2.00 per foot and make $1.30 on it, when regular rubber suction hose of the same size was sold from $5.00 to $8.00, according to quality.

And by the way, outside of the question of price, Purchasing Agent Roop of the North Pennsylvania Road told me that he preferred such canvas hose (devoid of wire), because there was not so much loss when tramps or others stuck their knives through it, as often happened.

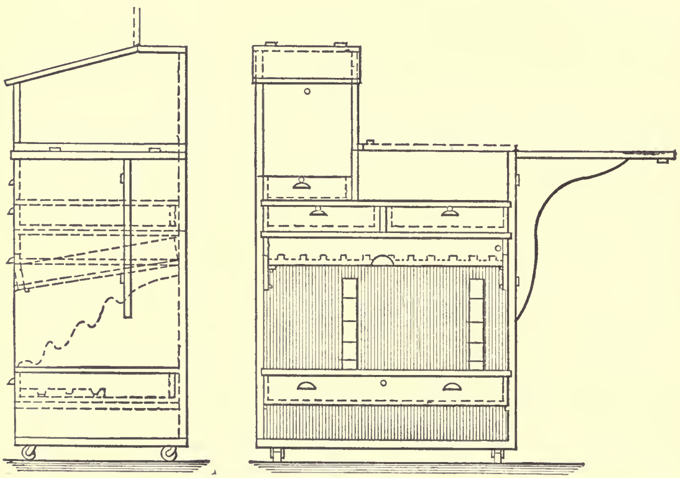
American Practicality is a by-word in Europe. I don't know that we deserve any credit for it; it is probably born with us just as a taste for music is with the Germans. Whenever I have been in Europe I have taken delight in showing our trans-Atlantic cousins, where possible, how much more practical ways we have of doing things than are in vogue over there. For instance, I was attending a meeting of a noted German society of engineers, of which I am a member; and one of my fellow-members, who had been connected with the building of the waterworks in a foreign city, was drawing on the blackboard, preparatory to reading a paper on the water-supply of that city, a map of the surrounding district, with canals, aqueducts, etc. In doing this he was making the outline of one side of the canals, etc., with an ordinary piece of chalk, and then going back and drawing the other bank with the same piece, as nearly parallel as he could (which was very nearly) and as rapidly as he could (which was not very fast). I stepped up and saying "pardon me," cut a nick in the chalk and showed him that it would do much better work and take much less time to draw both of the parallel lines at once. He stood for a moment astounded at the simple trick, and then he and several others who were standing by ejaculated, "*Wie praktisch!*" (How practical!)—as though almost any school-boy in this country would not have done the same thing just in that way.

Ordering Duplicates. If you want those pieces duplicated every now and then, don't send drawings down to the shops. Send the things themselves. The men's calipers will tell them what dimensions to give; there can be no mistake about what metal or other material is to be used, nor as to the number of each kind of piece to be made; and better yet, there will be uniformity of finish for each part and place.

An Inspector's Truck. In these days of interchangeable parts and of working to thousandths, inspection is a very important part of the machine-shop economy; and every pains should be taken to make it not only thorough in the first place, but inexpensive in the second. There are many machines like dynamos, machine-tools, and the like, which cannot well be brought to the inspector; so if the mountain will not go to Mahomet, Mahomet must go to the mountain.

To enable this to be done, with economy of time and money, and without cluttering up benches and interfering with the workman, the truck here shown should prove valuable in many shops, as it has before in those of the Brown & Sharpe Co.

There is a desk-like structure having one part, about thirty-four inches high, including the casters (which



FIGS. 212 AND 213.—INSPECTOR'S TRUCK. (BROWN & SHARPE.)

should be rubber-covered), and the other as high as is convenient for writing. That part to the right is flat; that to the left sloping. The former may be made wider by a flap which may be held rigid in a horizontal position by a hinged swinging bracket. There are compartments for the necessary books and stationery, others for small gages and tools; and below, racks for long screw-drivers and other pieces which may be more handily kept thus. The illustration is practically self-explanatory, and the idea is commended to dynamo-builders, makers of machine-tools, steam-engines, etc., as well as to manufacturers of sewing-machines, typewriters, and other small delicate machines.

Electric Annunciator. Where one man has to attend several tools or to attend one tool and do something else while waiting for it to get through its cut, it is well to have an electric annunciator to give an audible signal just before the cut is through. This may be done by having a brass rod pressed by a spring against the moving piece or against the carriage, and so placed that, when at a convenient distance from the end of the stroke or cut, it shall enter between two spring clips of sheet brass which are connected to an electric battery and bell, so that on the circuit being completed the bell shall be started ringing.

Tool-Lists. Not long ago I made a profitable visit to the world-famous shops of the Brown & Sharpe Manufacturing Co., in which for some reasons, and in some lines, there was less to learn there than in establishments where there is more building and less manufacturing. The science of making things in quantity, exactly alike, of the highest attainable degree of perfection, with the greatest capacity of production, and at the lowest cost, consistent with good work ; the business of making machine-tools as though they were sewing-machines, and milling-cutters as though they were buttons—to say nothing of the side lines of making sewing-machines by the hundred thousand—must of necessity call for special devices and systems, from which others may learn.

One of the predominant characteristics of this vast establishment is the business management which pervades every department, so that the visitor, while he cannot fail to be impressed with the fact that here unrivalled machine-work is done in metal, is equally impressed with the other fact that such work is not done for love, but must produce a profit—all the profit of which it is susceptible. It is the five per cent savings here, there, and everywhere that has enabled the concern to lower its price on standard machines 50 per cent in ten years, while keeping up and even raising the quality of workmanship and the quantity of metal.

One thing struck me—the profusion of both special and standard tools and appliances, at the same time that all there were in perfect order and condition, and none of them thrown one side or laid down carelessly. Down to a cold-chisel, every man is charged with each tool that he gets, and charged with it not merely as "one cape-chisel," but at a definite price, thus impressing him with the idea that it is not merely so many ounces of steel, but something costing money, worth money, and used for making money. This system is so much better than the plan employed in many large machine-shops that even the very details by which it is carried out should prove interesting and profitable.

The tool-list (copy of which is here given, and which is commended to the attention of machine-shop proprietors who are not in business for their health) enables an accurate account to be kept of just what each man gets, returns, spoils or loses. The actual size is 3⅝ x 10⅜ inches:

BROWN & SHARPE MFG. CO.

TOOL LIST.

Drawer No.............................

....*189*

Each workman is provided with a drawer with a lock, and will be held responsible for tools, at prices annexed.

No.	Name.	Price Each.	
	Lathe Board		
	" Tools		
	Oil Cans		
	Bench Brush		
	Tin Handle Brush		
	Thread Brush		
	Paint "		
	Files		
	File Card		
	Screw Drivers		
	Hand Tools		
	Scrapers		
	Center Drills		
	" Reamers		
	Vise Clamps		
	Cold Chisels		
	Wood Mallet		
	Brass Hammer		
	Lead Hammer		
	Drawer Key		
	Check No.		

Other tools needed can be obtained from the tool-room on leaving a check as receipt.

Tools to be delivered to the owner of the check only, and must be returned as soon as possible, that other persons wanting them may not be delayed.

All damage or loss of tools will be charged to the owner of the check, unless such damage or loss proves to have been unavoidable.

It is comprehensive without being cumbersome; concise without being indefinite and ineffective.

I cannot too highly commend the idea of charging tools at a price instead of as mere pieces of metal.

Scraping Fits for Steam-Engine Valves, etc. The usual way of making a scraping fit is to rub the two surfaces together in the same line that they are to follow in their movement when assembled in the machine, and to scrape away the metal that shows bearing; very thin red lead being rubbed over the surface in order that the bearing portions may show by being left clean after rubbing. But after this has been done several times the pores in the surface get filled up so that there is a dirty uniform rust-color which makes it difficult to see what parts bear and what parts do not. A better testing-material is spirits of turpentine, which evaporates rapidly and deposits almost instantly a thin visible film, without however making an accumulation of dirt.

How to Straighten that Shaft. It is not a difficult matter if you set about it right. That means center it properly, having prick-punched it and drilled or reamed it properly; and work the square center well while the shaft is turned as fast as you can; then a screw press which traverses the lathe-body is applied; and it should have wedge-blocks that may be brought nearly together or further apart at will, and should have on the top V's that can be raised. If the crook is long, the wedge-blocks are moved further apart; if it is short, then they should be closer together. Turn the shaft, and as it turns mark it with chalk every three or four inches all along; then the screw-press may be brought into operation.

After it is made straight, it should be squared true with a side tool; then the centers reamed again with the square center and drilled about an eighth of an inch deep with a small drill.

Etching on Steel. A recent recipe for etching brands and marks on polished steel surfaces calls for the procuring of a rubber stamp with the required design made so that the letters and figures which are to be eaten in by the acid shall be depressed in the stamp. Any one who starts out to get such a stamp will find himself in trouble. He must first go to a photo-engraver and get an intaglio (white on black) cut, which will cost him even more if the lettering is to be plain and regular than if it is not necessary to have it perfect. This photo-engraving (which will be just the reverse of what he would want for advertising purposes) he will have to take to the rubber-stamp maker. Once obtained, he is to use with it a resistant varnish or ink composed of resin and lard oil, in the proportions of about sixteen to one in bulk, with a little turpentine to thin it, and some lamp-black to make it show. The etching-fluid is one measure of nitric acid and one of hydrochloric to ten of water.

In order to be able to use the ordinary rubber stamps which can be got anywhere without resort to a photo-engraver, mix a small amount of gum with the acid, so that it will not flow too freely, and apply it with the stamp to the surface to be etched, taking care to apply the stamp squarely and to lift it away squarely.

For Cutting Steel Bars up to one and one-half inches square it will do to cut then on the anvil with a sharp cold-chisel from all sides, then laying a small fuller on the nick and forcing the pieces apart by a clean action.

In Grinding Flange-Joints by hand the effort of putting on sufficient pressure is considerable and tires the workman unnecessarily if he has legs. It is usually perfectly feasible to attach to the lap-plate a rope with a loop at the free end so that it may be hauled on by the foot, and the hands and arms used only for rotating the lap.

To Make Stencils Without Cutting-Tools, mark out on tough paper the desired outlines and cut them out to correspond with the stencils which are desired to be made in metal. Lay these paper stencils on thin sheet zinc; and with a sponge or swab moistened with hydrochloric acid (which some call chlorohydric, and others call muriatic acid) wet the zinc. The acid will very shortly corrode away the zinc so that it may be pushed through, and the outlines may then be filed smooth.

Cocking Wing-Valves. If you have wing-valves which cock in their seats, try the effect of giving the wings a slight taper. They are ordinarily made perfectly straight to prevent cocking, but as they do not make a perfect fit, the parallelism does not always prevent their cocking; and those who have tried say that with a slight taper they are much less apt to misbehave.

Brazing Cast Iron. I have just received a note from a friend in a distant town, asking me how to braze cast iron. I thought that every mechanic knew that. It may be done very readily by having the iron clean, making it free from grease and acids; applying a solution of borax to the surfaces to be joined; fastening the parts together, heating in a clear charcoal fire, and sprinkling on plenty of powdered borax and brass filings; getting the iron up to a red heat before any of the brass melts, yet being careful not to let any of the iron melt. When the brass runs, the pieces should be immediately removed from the fire, the superfluous brass wiped off, the pieces cooled slowly, and the joint then finished.

Gasket-Cutting. You are making a botch of that rubber gasket-cutting. If you will just wet your knife, you will come out better all around—better job, less trouble, and sharper knife at the end of the work. A little potash and water or soda and water would be better than pure water, if it was handy.

Die-Sinking. Drop-forging has got so much more common now than it used to be, and it being often inconvenient for those who have dies to make, it would be well for every shop to consider the question of die-sinking, both as a question of convenience and as a matter of economy.

There are many who have made failures out of a few dies and then have given the thing up in despair or disgust and send all their orders for dies, after that, to those whose regular business it is to do die-sinking and nothing else. But this is not wise. Even if it be found best to order one's dies regularly of a duly-ordained die-sinker, it is wise to know how to make one's dies oneself in case the die-sinker should be busy, or dead, or in some other way unable to do your work for you. The first thing to do should be to make a finished model of what you want to have forged, and having done it, to make some two-part plaster casts of it, to see how it "delivers." There is nearly always some one way in which it may be drawn better than another; and after the proper parting plane has been decided on, it will do to start in to make the die.

Fifteen cents' worth of time spent in making plaster casts of the model will sometimes save $15.00 worth of time spoiling good metal to make poor dies.

In many cases—perhaps in most cases—the form will admit of being struck up in one operation from commercial rod or bar; and in this case the next step after deciding on the parting-plane is to make a template representing the section of the article which would be made by that parting-plane. If the model is of wood (and it is best that it should be) it can be cut through with a very fine saw (the "very" being spelled with a capital V) right in that plane; then each half of the model will represent in relief (with the trifling exception of the discrepancy made by the saw-kerf) what the die should be in *intaglio* or sunken. The flat side of the cut of the pattern for the top die will serve as a print to mark out on the block for the under die, the lines within which to cut, and *vice versa*; that is, painting part *A* of the model and applying to the block that is to make part *B*, you will have the lines within which to cut; and painting the parting-section of part *B* of the model and applying it to the block in which the die for *A* is to be cut, you will have the outlines within which to work for the die of *A*.

If the model is of wood it will not hurt it to drill holes in it; and it will be well to draw on the parting-face of each half, lines a regular distance apart, and at right angles with each other, so as to divide the parting-side of each half of the pattern into squares. Then drilling down with a very fine wood twist-drill from the convex side of each part of the model, perpendicularly to the parting-face, from the most prominent parts, there will be a number of holes which will come out on the parting-face in certain positions with respect to each other and to the lines marking the squares. These points can be transferred to the ruled-off surface of the block; then drilling down from each of these points, to a depth within say one-fiftieth inch of the depth of the corresponding hole in the model, you will have witness-marks which when you mill in or rout out will tell you when it is time to commence to cut less boldly. By putting "red stuff" on the model and applying it from time to time to the work, always cutting in as long as there is any red transferred from the model to the excavation, and paying attention to the witness-marks, which will tell when to commence cutting more carefully, the dies may be made the proper reverse of the model, without any risk of overcutting.

This process will result in the formation of the one pair of dies necessary to do the work, if it can be done with one pair; and if it requires more than one pair, by successive forgings (as in the case of work which is very much spread) it will give the last pair; the other set or sets being made by the use of common sense and experience in the application of the principles just laid down.

Rubber Joints (or "gum" joints as they are called in Philadelphia) should before being put together be coated with chalk or with graphite (plumbago; black lead), which prevents the gum from sticking to the metal, and from being destroyed when the joint is taken apart. All gum joints in the water space of steam boilers should be coated with lead and tallow before being put together, thus preventing the sulphur of the rubber from attacking the metal and destroying its surface.

To Test Shellac, dissolve it in absolute alcohol, which will dissolve the shellac and leave the impurities. Absolute alcohol should indicate 1000 upon an alcoholometer. Pure alcohol will all burn away; that which has water in it will leave most of the water behind.

Marking Steel Tools may be done by covering them with wax, engraving the marks through the wax down to the level of the steel, and then etching with the following mixture: 1 ounce of sulphate of copper, 1¼ ounces of alum, ½ teaspoonful of salt reduced to powder with one gill of vinegar and 20 drops of nitric acid.

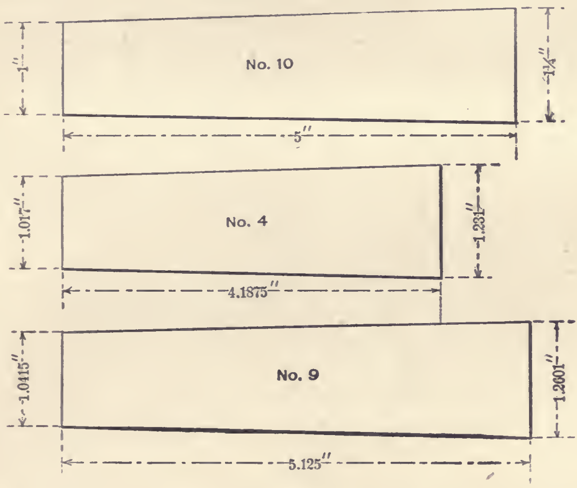
Rusting of Machine-Tools may be prevented by smearing the bright parts with a mixture of lard oil and kerosene in equal parts. For shipment, a mixture of tallow and lime will be found much better and cheaper than the usual "smear" of tallow and white-lead.

Reckoning Tapers. The ordinary way of reckoning or ordering tapers is so much per foot. This is inconvenient, especially as the articles are seldom any even number of feet long. It might be better to order the taper so much in one-hundred, and this could be readily reckoned and laid down by the ordinary rule graduated into one-hundredths.

The one-hundredth rule may also be used for a shrink-rule, as iron shrinks about one per cent.

But there should be a standard taper, no matter how reckoned.

Standard Tapers. One of the principal signs of our advancement in mechanics is our adoption of universal or at least general standards for so many things—screw-threads, gear-teeth, wire-gages, etc. We have not yet, however, quite got to perfection and general agreement in the matter of standard tapers, as for lathe-centers, arbors, collets, chucks, drill-press sockets, milling-machine spindles, and tapered parts of metal-working machines gener-



FIGS. 214 TO 216.—"JARNO" AND OTHER TAPERS. (BROWN & SHARPE.)

ally; and the multiplicity of tapers before existing makes it very hard to get any new one or even any old one adopted and used as a general standard.

I have been looking over the ground pretty thoroughly, and think that what is known as the "Jarno" taper (it being a pretty open secret that this originated with Mr. Beale of Providence) is practical in application and easy to remember and understand.

As shown in the annexed illustration, Figure 214, the rate of taper is always one in twenty; the tapers are numbered 1, 2, 3, etc.; the number of the taper designating the number of tenths of an inch at the small end, the number of eighths of an inch at the large end, and the number of halves of an inch in length. Thus: number 1 is one-tenth inch at the small end, one and one-eighth inch at the larger end, and one-half inch long; number 5 is five-tenths inch at the small end, and five-eighths inch at the large end, and 2½ inches long. The other tapers, Figures 215 and 216, are something and a fraction by something else and some other fraction; and their numbers have no relation to any of their dimensions or proportions.

An Item About the Dynamo. Many inventors are trying to get out of the dynamo a greater duty than is possible. Many others also, failing to see the principles on which the machine works, get poorer results than they should get.

If we move a wire in the "field" of a fixed wire, through which a current passes, the moving wire will have generated in it a current having an electromotive force proportionate to the intensity of the current in the fixed wire, to the speed at which the moving wire passes through the field, and to the effective length of the moving wire. The greater the speed the greater the electromotive force. By insufficient rotation-speed, or rather insufficient actual speed in feet per minute, irrespective of the number of turns per minute, there is obtained an electromotive force lower than should be possible. In building small machines designers are apt to forget that high rotation-speed does not necessarily imply high actual speed in feet per minute; and they expect an armature six inches in diameter, at six hundred turns, to produce the same electromotive force as one twelve inches in diameter at the same number of turns per minute. They also forget that in the small armature there will be fewer feet of wire moving. With fewer feet of wire and lower speed, it is not possible to get the same result, the intensity of the current in the fixed wire being the same.

A Simple Rotary Blower may be made by making a stiff light cylindrical drum, *A*, hung eccentrically and giving running (not standing) balance on a cock-head, and rotating it in another cylindrical drum, *B*,

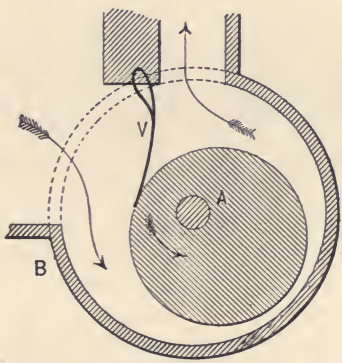


FIG. 217.—SIMPLE ROTARY BLOWER.

as shown in Figure 217; using as a valve a leather flap, *V*. It will not have to be driven at a high speed. The arrow shows the required direction of rotation.

Special Machines. The advantage of having special machines to do special work where there is much of that special work to be done (as in manufacturing, as distinguished from jobbing or occasional building) may be seen by a case cited in the *American Machinist*, where a workman, having some holes to make in machine steel, started a man at it with the result of a hole in five hours, while a Hartford builder of machine-tools has a machine guaranteed to make one every ten minutes. This is just thirty to one in favor of machine-work—if you have enough of the work to be done. It would not, however, pay to buy a $290 machine to do $29 worth of work, and perhaps not have another job of the same kind within two years.

Metal-Finishing Machine Wanted. There is one wood-working tool which might very well be imitated in the metal-working line—the sand-papering machine having a horizontal arm with from one to two hinge joints in its length, and bearing at its free end a belted horizontal sand-paper drum which is made to traverse every square inch of the upper surface of the piece, as a door, which it is intended to smooth. A similar jointed arm having free motion in a horizontal plane, and carrying an emery disk, would be very useful in drilling-machines, especially in boiler and bridge work where there is much drilling, reaming and countersinking to do all over the surface of work of considerable surface. Such a machine could be run very well with either a flat belt or a cotton or Manila rope.

The Double-Threaded Screw. An inventor came to me the other day with a machine in which he proposed, incidentally, to double the power of a screw by having it double-threaded; and it took me longer than the job is worth to convince him that, instead of his doubling the power by doubling the thread, he really halved it. Reference to the accompanying illustration of a double square-threaded screw should make the matter clear.

In any screw the pitch is the distance between centers of adjacent turns of the same thread, measured in a line parallel with the axis or center-line of the screw considered as a whole. Every time that the screw is turned once around in its nut, it will advance a distance equal to the pitch; half a turn giving an advance of half the distance, and so on. If the nut is turned on the screw, one complete turn advances it the amount of the pitch. Conversely, if the pitch is very fast or steep, and the screw is pushed in the

FIG. 218.—DOUBLE-THREADED SCREW.

nut or the nut pushed along the screw, advance of either, the distance of the pitch will cause one complete rotation of whichever one is free to turn.

The gain in power by a screw is, without deducting for friction, proportionate to the ratio between the distance that the power moves circumferentially or slightly spirally, and that through which the screw moves lengthwise. Thus if the screw has one-inch pitch, and a lever one foot long measured from the center line of the screw in a plane at right angles to the axis, and in a radial line in that plane, the theoretical gain in power (that is, the gain not allowing for the loss by friction) would be equal to $12 \times 6.2428 \div 1$ equals

74.9136; since the power that turned the lever would pass through 74.9136 inches in making the screw advance one inch.

If instead of having only one thread with a pitch of one inch there be two threads wrapped parallel with each other about the central cylinder of the screw, it is evident that, with the same width of screw-thread as with the single thread, the pitch will be doubled; and that every turn of the screw by its attached lever will advance the screw (or its nut) two inches instead of one. While at first glance this may seem to be doubling the power, it is in reality halving it; a force of one pound moving through the 74.9136 inches at the end of the lever will cause an advance of screw or nut of two inches, and thus increase the power only 74.9136 ÷ 2 equals 37.4568 times as a maximum; friction having to be deducted in this case as in the last, although it will not be the same for a double-threaded screw as for one with but a single thread.

If we wrap three parallel threads about the center or axis, the pitch will be three inches instead of one, and the power multiplied only 74.9136 ÷ 3 equals 24.9718 times as a maximum.

With a less pitch, say only one-half inch, a single thread with a twelve-inch lever will multiply the power $74.9136 \div \frac{1}{2}$ equals 149.8272 times; with a double thread the same as the last the pitch would be one inch and the power multiplied 74.9136 ÷ 1 equals 74.9136 times as in the case of the single-threaded screw of one-inch pitch. In every case, no matter what the pitch, nor what the number of threads, the maximum multiplication of power is equal to the distance that the power moves through in one turn, divided by the distance that the screw or nut advances in one turn.

It should be understood that the mere fact of having a twelve-inch lever will not cause the multiplication of the power unless the power is applied at the end of the lever. To apply the power at the middle of a twelve-inch lever would be practically having only a six-inch lever.

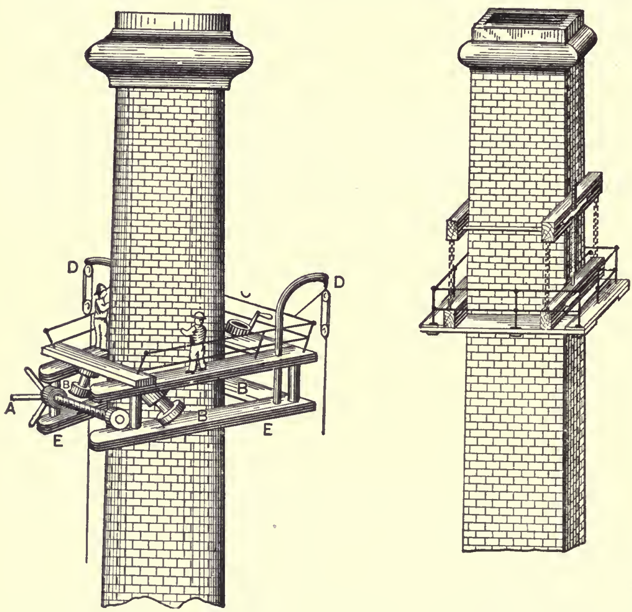
Having a lever then twelve inches long but applied in any other than a plane at right angles to the axis of the screw will not give the same results as where the lever lies in that plane. The actual lever is the shortest distance between the point where the power is applied and the axial line of the screw.

Chimney-Climbing. There should be a law against building any chimney or stack without climbing-irons either inside or out; because it is not right to endanger men's lives whenever a trifling repair has to be made.

The old-fashioned way of flying a kite over the chimney and trying to get the string to drop just right sometimes took several days. Next to that the ladder system is rather more certain, but unquestionably rough; and then it demands fine weather, and is very dangerous.

In Liverpool, England, the Alkali Co. had a big chimney which was successfully climbed by a rig got up by Brown & Porter of that city, and which I show as applied to a round and a square brick chimney; however, the second form may be used for those of a hexagonal or octagonal section also.

The staging shown in Figure 219 is three-sided and consists of an upper and a lower story connected at each corner by vertical clamps. At the left is seen a screw worked by the handle *A*, and serving to give a tight grip against the chimney; the two corners of the stage opposite this screw being hinged. Three rollers marked *B* are provided and set at an angle, one at each side of the three-sided staging. These bear against the chimney, and the one to the right can be turned around by a handle, worm and worm-wheel *C*. Turning this roller causes the entire staging to



FIGS. 219 AND 220.—CHIMNEY-CLIMBERS. (BROWN & PORTER.)

climb the chimney spirally. If the shaft is cylindrical, no adjustment of the screw *A* need be made; if it tapers, this screw will have to be gradually tightened as the stage ascends, in order to give the rollers enough grip.

Figure 220 has several advantages over Figure 219, in that it can be adapted to any form of chimney, and it is more readily operated. There are two stout timber grippers which may be fastened to the chimney by two long bolts, one each side of the chimney. To these timber grippers are hung by four chains two smaller ones also capable of being bolted to the chimney; and to these lower ones the stage is fastened. The lower and the upper grippers are also connected by two two-inch steel screws. The operation of climbing is as follows: suppose the upper grippers to be screwed fast and the lower ones to be loose, so that the stage weight will be held by the chains; working the screws, the stage is raised; when it is high enough, the lower grippers are fastened by tightening the bolts, thus taking the weight from the upper grippers. Then these may be raised still further by working the screws the reverse way; when the chains are tight again, the upper grippers are fastened as before, and the lower ones released, and so on.

Climbing a Chimney with Ladders. A long time ago an English firm built a chimney 320 feet high; outside diameter tapering from 17 feet 4 inches to 9 feet; and forgot to put climbing irons on it. When it became necessary to put on a new copper lightning-conductor and to repair the chimney, the work was done by using fifteen ordinary light painters' ladders weighing from 20 to 50 pounds, according to their length, and having an average width of 11½ inches at bottom and 10 at the top. Wooden distance-pieces were provided at the back of the ladders at the top to keep them off from the brickwork. The mounting was done by placing the first ladder at the base of the shaft, and driving a hooked wrought-iron dog or holdfast into the brickwork, four feet from the bottom of the ladder; then a second iron dog was driven into the shaft about four feet down from the ladder-top; and the ladder was lashed to these. The workman then climbed until he could reach about four feet above the first length, drove in another dog, to which he attached a pulley-block. One end of the pulley-rope was fastened half way down, a second ladder placed by the side of the first, and this second ladder hauled up by workmen at the base until it was half its height above the first ladder. It was then temporarily lashed to the first length; the workman climbed up it and drove another holdfast into the bricks, four feet above the top of the second ladder, shifted the pulley-block to the upper holdfast, and descended; then the second ladder was hoisted above the first one (which it overlapped two rounds) and its bottom lashed to the top of the first one. Then the climber mounted the second ladder (which was still held by the pulley-block and rope) and drove in a holdfast above, shifted the pulley-block, and proceeded with the third ladder as with the second; and so on. But when the under side of the cap was reached there was trouble, caused by a stone cornice projecting about three feet from the face of the shaft. At this point the ladder was fixed very firmly; another length was hauled up until its top was about five feet above the cornice, and this slanting length was lashed to the length below at its foot.

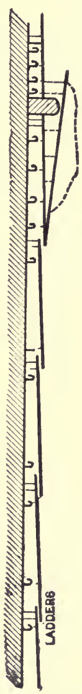


FIG. 221. CLIMBING A CHIMNEY WITH LADDERS.

at intermediate points, and also close underneath the cornice. When climbing this length the workman's back was towards the ground. The last ladder was hauled up and fixed above the cornice, reaching to the top of the chimney; and to the bottom of this the top of the slanting ladder was firmly lashed. It took five hours to do all this.

Fire Buckets. It seems that in some shops even a system of fines will not prevent workmen from using the fire buckets for washing their hands, or for other purposes entirely unnecessary and forbidden.

In the Newton shops that is not likely to occur, for they are all hung up and have conical bottoms, so that they could not be made to stand up without more trouble than even the most persistent would be apt to take in the matter.

Elevator Stop. Haskins has a handy rig for stopping an elevator at any point whether going up or

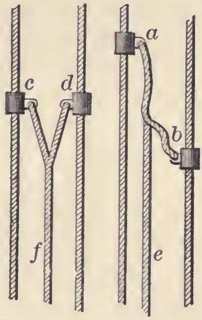


FIG. 222.—STOP DEVICE FOR ELEVATOR ROPES.

coming down. As shown in Figure 222, it consists of two ropes *c* and *d*, attached to a long rope *f*, extending to the bottom of the elevator well or to the first landing, and attached above the upper landing. When the elevator is started it occupies the position shown by letters *a* and *b*; but when it is desired to stop, pulling the rope *e*, the cords are brought into the position shown by *c* and *d*.

As to Scrap-Heaps. It is the wisest man who profits by experience. Most experience that may be profited by is expensive to some one or other; and this is the case whether it has been successful or unsuccessful. But as there is more unsuccessful than successful experience, it naturally follows that we may learn more from failures than from successes. The scrap-heap measures in great degree the quantity and kind of failures that take place, and there are many lessons which may be learned from it, as to how *not* to do things. If there are but two ways of doing a thing wrong we may probably find which one of them is the right one by the story of the wrong one as told in the scrap-heap. If there are thirteen wrong ways to one right one, we can still study the scrap-heap to find from one to thirteen of these wrong ways, and by induction we may find the fourteenth and right way.

I remember that a number of years ago I was called in to report on the desirability of equipping a very large brick-yard with a certain class of brick-machines costing about $15,000 apiece. There was a number of molds in a horizontal rotating table and having false bottoms which rose and fell by the action of a circular inclined cam-table, thus compressing the clay that was filled into the molds and then pushing out the compressed block as a "green" brick ready to be carried away and hacked. Each of these pistons or false bottoms had a wrought-iron stem with an anti-friction roller on the bottom ; and it seemed to me that these stems were always getting a bending stress which would not improve them in connection with the severe compressive strain thereon. I asked about this—if the machines were not troublesome from this cause, and was told that there was no difficulty whatever ; that they rose and fell without ever giving any bother or causing any expense for renewals. I took this statement with a grain or so of salt, and took occasion to look into a large chest in the corner, which it did not seem to me was a necessary part of the equipment of a brick-yard. I found in it quite a supply of spare "stems," and also a very much larger supply of broken and bent ones, cracked rollers, scored steel face-plates from the cam-table, and so on. From this scrap-heap I got my cue. I was sure that the builders were lying ; and the only way to prove it was either to stay around and wait for a stem to break, or to find the scrap-heap.

On another occasion I was commissioned to report as to the rock-drills for use in an important public work abroad ; and as I knew that in the United States work at Flood Rock (commonly called Hell Gate) there were examples of almost every kind of rock-drill used, I went there duly armed with a letter of introduction to the lieutenant in charge. Before presenting it however, I cast my eyes about for the scrap-heap, knowing that there I would find the record of broken and worn out parts, and would then be rather better posted as to the wearing of tappets, slide-valves, etc., than I would be if I trusted to the statements of those interested—no matter how honest they might be. The result was that I found a certain number of tappets of one machine; a certain number of slide-valves of another, and so on. What I saw very materially aided me in questioning those who were using the drills in their actual work, and in making up the report to my foreign clients.

I would say to every one who is either inventing or manufacturing any lines in which there are machines of other kinds at work—"keep your eye on the scrap-heaps." The inventor wants to know what parts of his rival's give way, so as to be able to avoid falling into similar errors; the manufacturer wants to know not only what parts of his rivals' machines are giving way, but what parts of his own are defective.

It does not, however, follow that the presence of a great number of pieces of a certain kind in a scrap-heap argues inefficiency on the part of the machine; as it is often cheaper to throw away one part than to refit it or to furnish it with facilities for adjustment or repair. But if there is any one part which should go into the scrap-heap it should be some small, unimportant piece that is cheap to make and easy to put in place. Of two wearing parts, that one should be the one to go into the scrap-heap which costs the least to replace. Thus, if there should be no difference in the quality and hardness of metal between a slide-valve and the cylinder which forms the seat on which it plays, the slide should be the softer, so that it may get the wear; as to reface it or to replace will be cheaper than to do the same with the cylinder.

The Language of Machines. Garner has been showing that brute animals, such as monkeys and others, have a language of their own by which they may communicate ideas to each other and by which he can in some cases impress ideas on them. There has long ago been shown to be a "language of flowers," but that is only figurative; of course, plants cannot tell one another what they want and think. But that machines have a language, there is no doubt; any old mechanic can understand it. Although he cannot make machines understand what he means, he can readily understand what they mean.

For instance, there is the screeching of belts. It takes a good mimic to imitate it, but almost any one recognizes it on first hearing. It means that they are oily, or that they are overloaded; for each trouble they have a distinct cry, just as a child has separate cries for the thirst of fever and for a stubbed toe.

Then there is the language of the engine; it may mean that the main bearing is loose and the crankshaft lifting at every stroke; or that the piston-rod is loose in the crosshead, or that the piston-head is loose on the rod, or that there is water in the cylinder, or that the steam-pipe is on too sharp an angle and "kicks" every time that the engine cuts off sharply, or that the valves are wrongly set, or any one of a dozen things.

Steam-pipes have really only two expressions. One is that to which I just referred, in connection with the steam-engine; an expression that they have been laid out and put in wrong. The other is a very appropriate hiss for those who have allowed joints to leak and steam to escape. No one should submit to have this imputation on his thoroughness as a mechanic continue to be hissed at.

A line of shafting has a cry of pain which shows how the delicate skin of the journal and bearing is being rubbed away by the lack of oil. No compassionate shop-owner or foreman should allow that cry of pain to be heard very long in any one place.

I could go on and multiply instances of the language of machines and their appurtenances, just to point out that those who watch to hear them may learn much which will benefit them and those connected with them. "None so deaf as those who will not hear" is an old saying and a true one. Some men go on day after day, hearing such noises and never paying any attention to them; in fact they get deaf to them—and some day they regret it.

Emergencies. About as good a subject as any other for a chat is that of emergencies. While it may not appeal just at the present moment to more than two per cent of my readers, the time will come when every one of them will probably remember with more or less thankfulness that at one time I called their attention to the desirability of being in time of peace prepared for war; and to the advantage that a man has, who is ready for emergencies, over one who is only ready for every-day work and conditions.

There are two principal classes of men who are never ready to meet any unexpected conditions or circumstances—the incompetent kind and the kind that get "rattled" whether or not they have in them the knowledge that would bring them out of the hole. Those of the first kind are much more likely to get experience than those of the second kind are to get steady nerve; but still, for all that, the first time that one has an engine run away with him, or gets caught by a fast-running shaft, or is confronted with the breakage of his best tool or the loss of his best help, difficulties do not seem to be quite so easily overcome as after about the twenty-first time; and some of the bravest soldiers are said to have been quite overcome by fear the first time that they were under fire.

There are in the country some establishments that have the reputation of being "big little shops," because of the size of the work that they turn out compared with the dimensions of the establishments or of the tools that they have in them. Such a concern used to be that of the Fletchers of New York City—who took the contracts for the noted Sound steamers "Puritan" and "Pilgrim," where some establishments about three times the size would not have dared attempt them. There are some shipyards in the country that I verily believe would undertake to dock a 500-foot steamer in a 300-foot dry-dock. They would manage it somehow, if they had to stand the boat on end or build a caisson all around one end of her, as a sort of bay window to the front of the dock.

Perhaps, instead of my generalizing very much to start out with, it will be much more interesting to my readers to go into particulars and recall some jobs that have been done with inferior appliances.

I remember once, when the dash-pots of an old side-frame Corliss engine were sent out to be re-bored and came back not bored down far enough, so that there was at the bottom of each pot a shoulder against which the plunger struck (I had only twenty-four hours to take the engine down, put in new piston-packing and new brasses all around, line up the whole engine and adjust the valves, and get it running again, and the shop was a good distance off), I chipped the bore out myself with what chisels I could find about the engine-room and got the machine turning over just about ten minutes before the mill had been absolutely sworn to start up. It was a cheeky piece of work to do, but it had to be done; it was in February, which was a short month, and the product of the mill in stated quantities had to be shipped by vessel the first of the next month, and as there were from two to three days short in that month anyway, and there had been several stoppages before the day used for the repairs, it was a matter of having to get there some way or other. It was a case like that of the services which were announced to take place on the following Sunday "in the morning, fine weather and Divine Providence permitting, and *in the afternoon whether or no.*" That flour had to be shipped whether or no, and the chisels removed the obstacle.

One of the best examples of doing work with insufficient appliances was seen at the Centennial in Philadelphia, where a young Russian engineer residing in that city took a seventy-five ton cannon out of a boat with a fifty-ton crane—by raising only one end at a time, blocking it up, and then going to the other end, until the cannon was high enough up to be rolled off on the wharf.

I have asked some of my friends to jot down for my readers' benefits some of their experiences in getting over one-hundred-foot streams with fifty-foot bridges, and their replies, given below, should prove as useful as they are interesting.

My old friend, Wm. M. Henderson, a veteran engineer from the "Land o' Cakes" and one of the earliest and most competent designers of steam fire-engines and hydraulic machinery in this country, tells the following:

"When I was one of the Government engineers in Chili, S. A., in charge of the building of stone bridges on the Valparaiso and Santiago R. R., being out on the line one day on a hand-car, my progress was stopped by a locomotive on the single line of road, about four miles out from Santiago. After waiting a reasonable time for the locomotive to back out of the way, I walked up to the engine, and found the engineer, a Mr. Ames, an American, under the engine, taking off the suspension-bar for operating the Stevenson link. As he got it off and handed it to me I saw it was blue at the joints. The pin was wrenched off. I remarked, 'That was caused by lack of oil. I wish you would back your engine on to the nearest siding to let me pass.' But the link had dropped into forward gear and he said it was impossible to back the engine, as he could not reverse. Now I was brought up in a locomotive-shop, and asked him if he would let me help him. He was only too glad, being on his beam ends. I procured a piece of rope out of the tool-box on the tender and looped up the link by taking a turn over the brass railing running around the engine, and when all was ready, told him to reverse the engine and give her steam. By standing on the platform and watching the movements, I manipulated the rope, slacking and tightening to accommodate the vibration of the eccentric-rod, and so allowed the engine to work backwards until we reached a siding about a quarter of a mile off, where I told him to draw his fire and bring the broken pin and plate with him, and I would take him into Santiago to the shops, where he could get it repaired. He seemed a little uneasy on the hand-car with me, a stripling whom he had never seen before. At last he remarked: 'You seem to know something about a locomotive!' 'Yes,' I replied, 'I served my time with James Edward McConnell, the inventor of many improvements in locomotive engines.''

Prof. John E. Sweet, formerly of Cornell University, and now at the head of the Straight Line Engine Co., is noted as one of the most fertile of American mechanical engineers in expedients; in doing a fifty-ton job with twenty-five-ton appliances and the like; but unfortunately for the community he is as modest as he is competent; and while most generous with valuable spoken advice in the hour of need, it is hard to draw him out for publication. But in addition to many valuable "kinks" and "wrinkles" already illustrated in this book, he gives this, much to our profit:

"At the Centennial there was exhibited a foot-lathe built by the students at Cornell.

"Not having a lathe large enough to either turn the pattern or casting, makeshifts were resorted to. The casting was made as large wheels commonly are, by sweeping up the rim and coring out the inside. The center hole in the casting was drilled under the drill-press and hand reamed. A pin to fit was set up in the bed of the planing-machine, the tool-holder served to hold and feed the tool, and student labor rotated the casting; the result was as good as any."

Mr. George L. Fowler, to whom the atmosphere of the machine-shop and designing-room has been familiar for more years than one would think to look at him, and to whom railway inventors naturally turn when, to use a homely phrase, they have bitten off more than they can chew, gives an item of his earliest experience in getting out of a hole by a ladder built of "gray matter."

"Once we were driving the shop night and day to get a job out on time. I had for night service a smart engineer whom I could not discharge because forsooth he occupied the relationship of nephew to four of the directors in the company. I left the shop one night about nine o'clock and my last words were, "Now don't meddle with the engine." I was just dropping off into a doze when there was a sharp rap on my door and the night foreman informed me that the engine had broken down. Of course I dressed hurriedly and rushed off to the shop, which I reached just in time to head off the men who had washed up and were leaving.

"The eccentric-strap was broken. At first visions of moving the valve by hand came to me, but my eye caught sight of an old wood chuck. Sending a man after a wood-turner, I hauled over a lot of the wood chucks until I found one about the diameter of my eccentric. This I clamped into position, fastened the rod to it, set the valve and started up. Plenty of grease, a stop once an hour to tighten the strap bolts and reset the valve, kept the shop running up to speed till morning. Meanwhile the wood-turner had made a pair of straps out of some dry maple. These were thoroughly saturated with hot tallow, and before the day shift started to work were put in position and the valve set. By tightening the bolts slightly once or twice a day and drawing up the eccentric-rod till the valve-stem trammed all right, we used those wooden straps till a pattern could be made, castings procured and new straps fitted. I think we lost half an hour's time, and the engineer lost his job because he thought the eccentric-straps needed tightening just a 'leetle.'"

Mr. F. J. Masten, a veteran mechanic, contributes the following, in which the practical and the drily humorous are truly blent :—

"While I was a journeyman machinist at the Defiance Machine Works, a pulley about five feet by twenty inches, with its shaft, was brought in for repairs. The pulley had been held on the shaft by two feathers quartering. (No, they were not feathers, for they had not been sunken into the shaft ; but were projections of solid metal, and perhaps might be called processes.) These projections had been produced by cutting away the metal between, on a planer, and this plan was devised to avoid marring the shaft by keyways or feather-sockets. The shaft and its processes were all right, but the pulley had become loose, and had been run so, until the bridge between the two slots was entirely cut away, leaving but half the bore of the pulley.

"The Turnbull Wagon Works were shut down and several hundred men were idle from want of that pulley. It would take nearly a week to make a new one, and the problem was: Can the old pulley be made to serve longer, and be ready in place within eighteen hours?

"A heavy wrought-iron band was shrunk on each end of the hub ; then the space between the two projections was considered as a keyway, a corresponding recess was cut in the hub of the pulley, and the key, a huge affair, was concaved to fit the form of the shaft.

"It was not a handsome job when done, but it served the purpose well, and Mr. Turnbull was perfectly satisfied when he started his works, after the loss of but one full day.

"To be complete in all its parts, an emergency job needs a dramatic element in the form of a hero.

"The true heroism in this case was displayed by Mr. Charles Seymour, who was then Superintendent of the Defiance Machine Works. When the job was first presented, it was looked over by Mr. Seymour, the foreman, and me; and, according to military precedent, the one of lowest rank was asked first for his opinion. I took a little time to consider, and then said: 'Why not use the two projections on the shaft for the two walls of a keyway, and let the half bore of the pulley that is good serve to hold the pulley true on the shaft?' 'You are right, Mr. Masten,' said Mr. Seymour, 'in that way we shall get all there is of it.'

"Here was true manly independence and executive ability in a Superintendent.

"Then, soon after the work was started, Mr. Turnbull, and the President of the Machine Company, Mr. Kettenring, came along and manifested some surprise that it was thought possible to use the old pulley. 'Yes,' said Mr. Seymour, 'Mr. Masten has suggested an idea that will enable us to make a good job with the old pulley!'

"Such heroism is seldom seen in Superintendents!"

Invention in an Emergency. The following account is from Mr. D. L. Lyon, formerly Secretary of J. A. Fay & Co., Cincinnati, a concern that has done much to extend the fame of American mechanics for performing impossibilities, and to set the pace to rivals at home and abroad:

"Any one who has made any study of wheel machinery is aware that the throat of a spoke, which is the part above the tenon that is driven into the hub, was formerly made on a single spoke-throating machine, where one side was cut out at a time. In large shops they had two of these single spoke-throaters, one being right-hand and the other left-hand. One operator would throat the spoke on one side, and if the works were very large there would be another man at the other machine and he would throat it on the opposite side. The throating had to be done very carefully, because the corners were liable to be broken off if the man fed the spoke over the heads with a jerky motion. At one of the wheel-shops here in the city some man had got up an attachment for making a peculiar shape of throat on his single spoke-throating machine. He called his machine a double throater, because it really did double work. That is to say, when any one required a throat of this shape they were not compelled to take the spoke to another machine after it had been throated.

"Shortly after this double throater had been brought out one of our customers asked if we could furnish one. We replied that we could, and took his order for one with a complete outfit. After part of the machines were completed he inquired how the new double throater was coming on. We replied that we were making some progress; then he explained that he expected it to throat both sides of the spoke at once; in other words, cut both top and bottom of the spoke at once as it was fed through between two heads. We replied that nothing of this kind had been accomplished in the past, and that we proposed to furnish a throater with an attachment similar to the one made here in Cincinnati by the man in one of the wheel shops referred to above. He said this would not do, and accordingly he took one of our old-style single throaters. This remark, however, suggested to Mr. Doane that he could possibly make a machine that would throat both sides of the spoke at once. He perfected a machine where the material was fed through by hand and the heads were hung above and below the spokes so that both throats were cut on the spoke at one handling and at one passage. Then he thought that it might be arranged so that the tenons could be cut at the same time with the throats. This was accomplished, and finally he thought that we might make a machine that would cut the tenons, the miters for patent Sarven spokes, and the throats on both sides at once and use a power feed. This was accomplished, and we made a machine which will tenon, miter and throat as high as 15,000 spokes a day, as compared with the old-fashioned single throater where one man could throat only 3,500, and where a separate tenoning-machine was used for the tenons and a separate mitering-machine for the miters."

THE END.

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